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ON THE
PROTOTYPE OIL SHALE
LEASING PROGRAM

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PROTOTYPE OIL SHALE LEASING PROGRAM

January 1, 1980 through December 31, 1981

U. S. Department of the Interior
Minerals Management Service
Oil Shale Office
131 North 6th Street, Suite 300
Grand Junction, Colorado 81503

March 1, 1982



United States Department of the Interior

OFFICE OF THE SECRETARY

Minerals Management Service

Oil Shale Office

131 N. 6th, Suite 300

Grand Junction, Colorado 81501

March 15, 1982

This management report has been prepared for the information needs of the public and the Secretary of the Interior under authority contained in Code of Federal Regulations, 30 CFR 231.3(c)(3). It is the second in a planned series documenting programmatic responsibilities and accomplishments including lease supervision, condition of the leased land, and compilation and analysis of environmental and operational data.

The first report on the Prototype Program was issued in 1980 and covered the period from lease issuance in 1974 through calendar year 1979. This report covers calendar years 1980 and 1981. Subsequent reports will update information in each of the subject areas.

The interpretations and conclusions contained in this report are those of the Oil Shale Office.

Persons interested in further information on the Prototype Oil Shale Leasing Program are encouraged to contact or visit the Oil Shale Office, 131 North 6th Street, Suite 300, Grand Junction, Colorado 81501, or to call (303) 245-6700 (FTS: 322-0281). The Minerals Management Service in Grand Junction, Colorado, maintains a wide selection of oil shale documents on open file, including the lessees' development plans, annual reports, and environmental monitoring data. These documents are available for public inspection from 8:00 am to 4:30 p.m. weekdays. Many of these reports also are available at public and university libraries in northwest Colorado, eastern Utah, and at the office of the Oil Shale Environmental Advisory Panel, Room 1010, Building 67, Denver Federal Center, Denver, Colorado 80225, (303) 234-3275 (FTS: 234-3275).

Peter A. Rutledge

Deputy Minerals Manager-Oil Shale

ERRATA

Page 13, second paragraph under heading Bonding should read:

"At the present time there are \$300,000 reclamation bonds on both the C-a and C-b tracts. These bonds were based on the approved detailed development plan in accordance with Section 9(b) of the lease. Recommendations to BLM are being prepared to increase the bonds based on 1982 dollars."

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EXECUTIVE SUMMARY

This is the Oil Shale Office's (OSO) 1982 Report for the Prototype Oil Shale Leasing Program (POSLP) for the period January 1, 1980, through December 31, 1981. It summarizes developments on Federal Tracts C-a, C-b, U-a and U-b, shale oil production from Tract C-a, and the environmental effects of these developments. It includes a brief history of the POSLP, the terms and stipulations of the prototype oil shale lease, and the lease management responsibilities of the OSO. The appendices contain a detailed chronology of the POSLP and tract developments and the legal descriptions of each tract.

Status of Tract Development

Tract C-a

Approximately 26,000 barrels of shale oil were produced from two MIS (modified in situ) retorts on Federal Tract C-a. The demonstration MIS retorts were successful and no further testing of MIS retorts is planned. The lessees are building a pilot plant to test the Lurgi-Ruhrgas surface retort. They plan to develop the tract by open-pit mining and surface retorting, but these plans depend on legislation now in Congress to allow off-tract waste disposal and siting of plant facilities.

Tract C-b

The lessees of Federal Tract C-b sank and started to equip three shafts through the mining zone: A Ventilation/Escape, a Service, and a Production Shaft. On December 17, 1981, the lessees announced a delay in tract development. Engineering studies on the MIS and surface retorting processes suggest that they are not feasible at the planned scale at current construction costs, interest rates, and oil prices. The shafts will be equipped and reclamation will continue while an alternative to the MIS plan is prepared.

Tracts U-a and U-b

The development of Tracts U-a and U-b have been suspended since 1977 due to litigation over title to the tracts. The lessees plan to jointly develop both tracts as the White River Shale Project (WRSP). In September 1981, White River Oil Shale Corporation submitted a Detailed Development Plan (DDP) describing a three-phase plan to develop Union B, Superior, and Tosco II retorts. Shale will be extracted by room-and-pillar mining. Commercial production of 106,300 barrels per day is planned by 1993. Pending the Court's decision to lift an injunction against the U.S. Department of Interior, the OSO is expected to approve the DDP in early 1982.

Effects of Tract Developments on the Environment

Developments to date on Tracts C-a and C-b have neither permanently nor significantly affected the natural environment. (Because activity on Tracts U-a and U-b has been suspended since 1977, the environment there is unchanged.) A summary of the environmental effects of tract development to date includes:

Air Quality - There have been no permanent effects on air quality by tract development on C-a and C-b or shale oil production from C-a. Short term effects have been minimal.

Hydrology - Mine dewatering at C-a and C-b lowered ground water levels immediately adjacent to the shafts on each tract. Reinjection of excess mine water at other sites on the tracts raised local ground water levels. Naturally occurring ground water levels would be restored if dewatering and reinjection stopped. Mine workings on both tracts and the two demonstration MIS retorts on Tract C-a have locally altered aquifer permeability.

Biological Resources - Tract development at C-a or C-b had no measurable effect on flora or fauna on or near the tracts. Mule deer populations have declined since 1978, but this is related to regional weather patterns, food supply, and predation.

Geological Resources - Tract development to date has consumed an insignificant amount of oil shale resources underlying each tract. Data collected to date suggest that variations in shale oil yield and sulfur content are primary depositional features.

Scenic and Cultural Resources - All identified cultural resources have been protected or removed from areas disturbed by development. While scenic resources have been generally unaltered, the headframes of the three shafts at Tract C-b are visible from the Piceance Creek Road.

Reclamation - Except for the acreage actually utilized for plant sites and roads, all previously disturbed areas have been reseeded and reclaimed to a condition closely approximating the natural state. The erosion rate on the lease tracts is equal to the natural rate of degradation.

Health and Safety - While two fatalities have occurred, the incident rate for accidents on the federal tracts is significantly lower than the average rates for the oil shale industry, for underground metal or non-metal mines, and for coal mines.

To date, tract development and shale oil production have not been at a scale large enough to significantly affect the environment. When commercial operations commence, the production of more than 50,000 barrels of shale oil per day from each tract will produce major, presently unknown effects on air quality, water resources and quality, land use and productivity, and biological resources (flora and fauna). As development expands to commercial size, the OSO will monitor the environmental effects to ensure environmental integrity of the tract and adjacent areas. Environmental safeguards, restoration, and reclamation will be incorporated into a commercial, mature oil shale industry.

I. INTRODUCTION TO THE PROTOTYPE OIL SHALE LEASING PROGRAM

A. Resource and Development

"Oil shale" is a fine-grained, dolomitic marlstone containing a solid organic matter called "kerogen." Kerogen was formed from the remains of aquatic organisms, algae, and pollen grains that settled to the bottom of ancient lakes about 50-60 million years ago. Synthetic crude oil and gas are produced from kerogen by "retorting." Oil shale is heated to a pyrolysis temperature of 800° to 1100°F (400° to 600°C). The solid kerogen decomposes into oily vapors and gas. Residual carbon remains on the inorganic fraction of the shale.

Retorting can be carried out either in surface facilities or in the ground (in situ). There are two basic types of surface retorts: (1) direct-heated retorts, where pyrolysis heat is provided by combustion of the residual carbon within a moving bed of crushed, retorted oil shale; and (2) indirect-heated retorts, which use a medium that is heated outside of the retort vessel and then mixed with the raw shale.

There are also two basic methods for in-situ retorting: (1) True in situ - This involves fracturing the strata or dissolving the soluble minerals sometimes associated with the in-place shale. The shale is burned directly, or a working medium heated on the surface is circulated through the fractured shale. (2) Modified in situ (MIS) - In this process, 20 to 40 percent of the in-place volume of the oil shale is mined by conventional methods. The remaining shale is rubblized into the mine voids and burned or is indirectly heated.

Combustible gas, as well as petroleum liquids, are produced during retorting. Indirect-heated retorts usually produce a high-BTU gas, which can be used like natural gas. Direct-heated retorts produce a low-BTU gas, which is diluted by nitrogen, carbon dioxide, and other products. The low-BTU gas can be burned to make steam needed in the retorting process or to generate electricity.

Oil-shale retorts were first built in Colorado as early as 1917 and in Utah by 1919. By 1925, more than two dozen, small oil shale plants were operating. Shale for these operations was obtained from small pits and mine adits located at oil shale outcrops. None ever produced more than a few thousand barrels of shale oil before being driven out of business by the discovery of conventional oil and gas fields. Major research into domestic, commercial shale-oil production began in the early 1940's at the U.S. Bureau of Mines' experimental facility at Anvil Points, Colorado. Figure 1 shows the location of current oil shale operations. Table 1 lists the status of these projects.

Large quantities of potentially valuable sodium-carbonate ("saline") minerals are also associated with oil shales. There are an estimated 64 billion tons (5.8×10^{10} t) of trona ($\text{Na}_2\text{CO}_3 \bullet \text{NaHCO}_3 \bullet 2\text{H}_2\text{O}$), a source of soda-ash, in place in the Green River Basin of Wyoming. Twenty-nine billion tons (2.6×10^{10} t) of nahcolite (NaHCO_3), a potential scrubbing agent for industrial stack gases, and 19 billion tons (1.7×10^{10} t) of dawsonite ($\text{NaAl}[\text{OH}]_2\text{CO}_3$), a potential source of alumina, are interbedded with oil shale in the Piceance Creek Basin of Colorado. Proposals to co-produce these resources are pending.

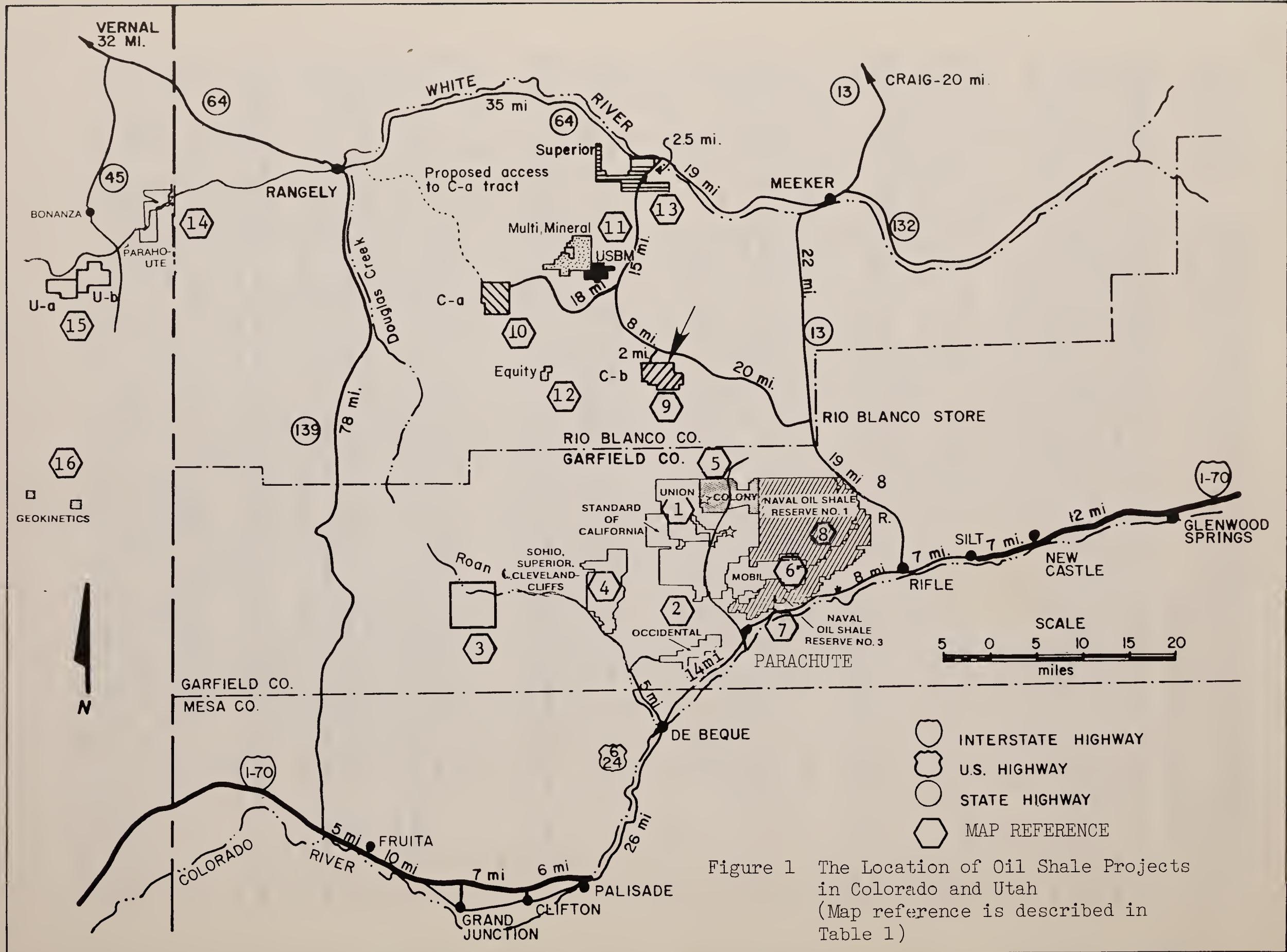


Table 1. Status of Western Oil Shale Projects and Research Sites as of December 1981
 (Based on published articles)

Project	Technology (MIS=Modified In Situ) (AGR=Above Ground Retort)	Status	Estimated Production (bbls/day)	Mining Zone	Water Use	Projected Peak Employment (C=Construction) (O=Operation)	Map Reference
<u>Colorado Projects</u>							
Cathedral Bluffs (Tract C-b)	Multiple level underground room & pillar mining for MIS development feeding Union B rock pump AGRs	After equipping commercial mine shafts, construction of mine support facilities will be delayed to evaluate engineering alternatives	117,000 by mid 1990's	Mahogany to top of L-5	9,900 AF/Y	C = 5,200 O = 4,400	9
Chevron Clear Creek	Underground room & pillar and open pit mine feeding Staged Turbulent Bed AGRs	Permit acquisition and plan review thru Colo Jt Review Prcs	100,000 by 1992	UG Mahogany Z Rf thru R-7	30,000 AF/Y	C = 9,700 O = 3,000	3
Colony	Underground room & pillar mine feeding TOSCO II rotating kiln hot ball AGRs	Completing mine bench, plant site, and worker housing	48,300 by 1985	Mahogany Zone	10,800 AF/Y	C = 6,567 O = 2,085	5
Equity	In situ superheated steam injection for kerogen recovery from Leached Zone	Completing initial two year field injection test	1,000 no commercial plans	Leached Zone	2,000 BPD fm leached zone	No data	12
Mobil	Underground room & pillar mine feeding yet-to-be-selected AGRs	Planning and environmental monitoring	50,000-100,000 by mid- to late 1990's	Mahogany Zone	No data	C = 2,200 O = 919	6
Multi Mineral	Rubblization stoping with undergrond nahcolite recovery and crushing with stope back stowage & MIS retorting followed by dawsonite leaching (Integrated MIS)	Submitted mine plan to USGS for sodium lease, exprmntl mine stopping at USBM Horse Draw site; completing 50-ton test retort at G.Jct lab	50,000 by 1988 (9,000 TPD nahcolite & 900 TPD dawsonite)	Saline Zone	No data	C = 400 O = 200	11
Naval Oil Shale Reserve #1	Probably underground room & pillar feeding yet to be selected AGRs, if commercialized	Preparing EIS, community plan, and master development plan	50,000 to 200,000	Mahogany Zone	No data	No data	8

Project	Technology (MIS=Modified In Situ) (AGR=Above Ground Retort)	Status	Estimated			Pr Pk (C=Construction) (O=Operation)	Employment	Map
			Production (bbls/day)	Mining Zone	Water Use			
Occidental Logan Wash	Multiple level underground mining for MIS preparation	Rubblized near-commercial-scale retorts 7 & 8 to be ignited Dec. '81	Non-commercial	Mahogany thru R-6	No data	O = 450	450	2
Paraho Anvil Points	Underground room & pillar mine feeding experimental vertical shaft AGR	Completed test runs at Anvil Points that have produced more than 100,000 bbls	Non-commercial	Mahogany Zone	1/2 bbl water/bbl shale oil	O = 30 to 128	30 to 128	7
Rio Blanco (Tract C-a)	Developing MIS technology thru surface drilled blastholes. Desire to use traveling open pit mine feeding Lurgi AGRs	Completed test MIS retort #1 burn. Awaiting off-site legislation. Preparing commercializat'n plans. Testing Lurgi pilot plant.	100,000- 300,000	L-8 to L-00	14,000 AF/Y	O = 2,500	2,500	10
Superior	Retreating underground room & pillar mine feeding multi-product recovery Superior circular gate AGRs	Appealing land exchange decision	11,586 (4,878 TPD nahcolite & 580 TPD alumina)	Lower Saline Zone	100 AF/Y	C = 1,300 O = 920	1,300 920	13
Superior Pacific	Underground room & pillar mine feeding Superior circular gate AGRs	Phase I engineering & permit acquisition	50,000 by 1989	Mahogany Zone	No data	C = 2,800 O = 1,400	2,800 1,400	4
Union Long Ridge	Underground room & pillar mine feeding Union Rock Pump AGRs	Completed initial mine development and plant bench. Building upgrading faclty	10,000 Phase I 90,000 Commercial	Mahogany Zone	8,000 AF/Y	C = 4,650 O = 1,110	4,650 1,110	1

Project	Technology (MIS=Modified In Situ) (AGR=Above Ground Retort)	Status	Estimated Production (bbls/day)	Mining Zone	Water Use	Pr Pk Employment Map	Refer-
						(C=Construction) (O=Operation)	
<u>Utah Projects</u>							
Geokinetics	Shallow-burned true in situ	Burning commercial scale test retorts & securing permits for commercial operation	2,000 by 1982	Shallow Mahogany Zone	None required	O = 150	16
Paraho-Ute	Underground room & pillar mine feeding Paraho vertical kiln AGRs	Completing feasibility, design, and engineering study	38,250 by 1986	Mahogany Zone	2,247 gpm	C = 1,500 O = 1,300	14
White River (Tracts U-a & U-b)	Underground room & pillar mine feeding Superior, Tosco, & Union B AGRs	Completing development plan approval, commercial design, permit acquisition, & lifting injunction	113,950 by mid- to late 1990's	Mahogany Zone	22,600 AF/Y	C = 5,083 O = 3,353	15

B. History of the Prototype Program

About 72 percent of the 11 million acres (4.5×10^6 ha) in Colorado, Utah and Wyoming underlain by shale potentially suitable for commercial development is federal land. These lands contain about 80 percent of the high-grade oil-shale resource.

In early 1970, a task force established within the U. S. Department of the Interior (DOI) evaluated the development of oil shale. Based on the task force's recommendation and the President's energy policy of 1971, DOI solicited nominations for tract sites on federal lands that had a potential for commercial development. Public hearings were held and concurrence was obtained from the Governors of the three affected states. Terms for leasing and a 3,200 page, six-volume environmental impact statement were released in August 1973.

In November 1973, the Secretary of the Interior announced the Prototype Oil Shale Leasing Program (POSLP). A Notice of Sale was published in the Federal Register on November 30, 1973. Sealed, competitive bids for leases on six, 5120-acre tracts (two each in Colorado, Wyoming, and Utah) were opened by the Bureau of Land Management on January 8, 1974. Bids totaling \$449 million dollars were received for four tracts. No bids were received for the Wyoming tracts. The special terms and unique stipulations of the POSLP are described in Part II of this report.

After leasing, the administration of the tracts and enforcement of the lease terms became the responsibility of the U. S. Geological Survey (USGS) in accordance with Department of Interior management procedures. A special program office, the Oil Shale Office (OSO), was subsequently established within the Conservation Division, USGS, in Grand Junction, Colorado, and now has a 20-member multidisciplinary staff. In 1982, these responsibilities were transferred to the Minerals Management Service (MMS).

C. Goals of the Prototype Program

The MMS has the responsibility to administer the POSLP within federal regulations, lease terms, and environmental practices. Four goals were stated by the Secretary of the Interior:

1. To provide a new source of energy to the nation by stimulating the development of commercial oil-shale technology by private industry;
2. To ensure the environmental integrity of the affected areas and, at the same time, develop a full range of environmental safeguards and restoration techniques that will be incorporated into the planning of a mature oil-shale industry;
3. To permit an equitable return to all parties in the development of this public resource; and
4. To develop management expertise in the leasing and supervision of oil shale development in order to provide the basis for future administrative procedures.

D. Lease Administration and Management

Described below are the relationships between the OSO and other federal agencies in administering and monitoring the POSLP.

1. Leasing Authority

Authority for leasing under the POSLP comes from the Mineral Leasing Act of 1920 (41 Stat. 437), as amended (30 U.S.C. S. 181-263), subject to regulations in 30 CFR 231 and 43 CFR 23 and group 3000. Together, these provide for leasing of public lands containing valuable mineral or fuel deposits, including extraction of shale oil and associated economic minerals.

2. Bureau of Land Management

Secretarial Order 2948 of October 6, 1972, sets forth the division of responsibilities between the Bureau of Land Management (BLM) and the USGS (now the MMS) for the administration of onshore mineral leasing and operating activities, which includes oil shale.

The BLM is responsible for issuing mineral leases and is the office of record in leasing matters. Prior to issuance of the oil-shale leases, the BLM represented the Secretary of Interior and issued permits for oil shale exploratory drilling. After the leases were issued and until they are terminated, the MMS is the sole representative of the Secretary in matters relating to the supervision of oil-shale operations. The BLM maintains responsibility for activities on public lands outside the leased area and for other activities, e.g., grazing on the lease sites. The BLM is consulted by the OSO on the surface use, environmental protection, and reclamation plans for all leased tracts.

3. Minerals Management Service (MMS)

The MMS (formerly the USGS-Conservation Division) has two major functions: (1) evaluation and classification of federal lands for their mineral character and value prior to lease or land exchange; and (2) supervision of operations necessary to the prospecting, development, and production of minerals on federal and Indian lands. Both functions are concerned with discovery, evaluation, receipt of fair market value, efficient development and conservation of leasable minerals belonging to the United States, and restoration of the environmental quality of those lands affected by mineral operations. Lease supervision includes the responsibility for determining applicable royalty charge and for collecting royalty income from all leased federal and Indian lands.

Within the MMS, the Oil Shale Office enforces lease terms and stipulations and continues to ensure that the programmatic goals outlined by the Secretary of the Interior (preceding page) are met. The structure, functions, and achievements of the Oil Shale Office are fully discussed in Part III of this report.

4. Oil Shale Environmental Advisory Panel

The Oil Shale Environmental Advisory Panel, "OSEAP," was established on February 27, 1974, by Secretary of the Interior Rogers Morton. The major objectives of the Panel are to assist the Department in attaining the goals of the prototype program; to ensure maximum public participation; to advise the Deputy Minerals Manager for Oil Shale and the BLM District Managers on environmental matters related to the Prototype Oil Shale Program; to advise the Department of Energy upon special request to the Interior Department; to respond promptly to public requests for advice; and to assist Interior officials in conducting public hearings. It carries out its key advisory mission by reviewing in public meetings all significant plans, actions, and developments for the responsible Interior field officials and providing advice and recommendations to them for their use in decisionmaking. The authorized membership of 30 represents concerned Interior bureaus and offices; other key federal agencies; the states of Colorado, Utah, and Wyoming; the counties affected by prototype oil shale leases, public members from the environmental/public interests; the energy/industry sectors; and the public at large.

OSEAP has met 34 times since it was established. All meetings are open to the public and have been held throughout the oil shale region in communities to be affected by oil shale development. During the calendar years 1980 and 1981, the Panel met a total of six times to formally review and advise Interior officials on nine major items and to make four recommendations to the Office of the Secretary. In addition, the Chairman conducted four public hearings for the Deputy Minerals Manager for Oil Shale on lease development plans.

II. THE PROTOTYPE OIL SHALE LEASE: SPECIAL TERMS AND STIPULATIONS

The POSLP is based on the terms and conditions of the Prototype Oil Shale Lease. These require the lessee to develop baseline environmental data; submit detailed development plans for each tract; and implement plans for reclamation, environmental monitoring, and mitigation. In addition, the lessee must pay a bonus bid and royalties, but may offset some payments by tract development. These special terms and stipulations of the Prototype Oil Shale Lease are more fully described below.

A. Baseline Program

Prior to the start of development, each lessee completed two years of detailed evaluation of physical and biotic aspects of the tracts and the immediate surrounding area. The various exploration/baseline programs had to be approved by the OSO before data could be collected on plants, animals, climatic conditions, air quality, hydrology, water quality, geologic structure and resources, and cultural or scientific resources. The baseline program was completed by November 1976 and data were compiled into baseline reports against which future development-related impacts could be evaluated.

B. Detailed Development Plans

After the collection of baseline environmental data, the lease required that each lessee prepare a Detailed Development Plan (DDP). The DDP describes baseline conditions and methods for resource development and environmental safeguards. The DDPs were reviewed by the OSO for technical completeness and feasibility, compliance with lease terms and applicable regulations, attention to environmental management, and suitability of planned or demonstrated reclamation of disturbed areas. The OSO also consulted with other agencies, held public hearings, received advice on environmental matters from the OSEAP, and obtained concurrence for approval from the Assistant Secretary's office. After a one-year period of suspension of operations to resolve technical and environmental matters, the DDPs for the two Colorado tracts were approved by the OSO in the summer of 1977. The lessees began on-tract development, subject to continuing OSO inspection.

Either the lessee or the OSO may propose modifications to the approved DDPs at any time. All modifications require approval by the OSO. To date, DDPs for both Colorado tracts have been revised to incorporate changes in shale oil extraction.

A DDP was submitted for the joint development of the two Utah tracts. Approval and implementation of that DDP, however, was enjoined by Federal District Court ruling pursuant to Utah's in-lieu land selection suit against the U.S. Department of Interior and over prior claimants to areas encompassing Tracts U-a and U-b.

C. Environmental Monitoring

Lease environmental stipulations also require the lessee to conduct monitoring during and after development. The environmental monitoring program must be

based on exploration/baseline findings and, thereafter, must quantify changes from baseline conditions and determine whether such changes are in response to natural trends or directly related to tract development. The monitoring programs routinely gather information on several hundred parameters throughout life of tract operations, including air and water quality, meteorology, hydrology, flora and fauna, health and safety, geotechnical conditions, and development impacts. The complex monitoring programs were approved by the OSO prior to implementation.

The baseline program was phased into environmental monitoring programs during 1978 and early 1979 as tract development began. Problems of implementation and operation of monitoring programs were worked out by the lessees and the OSO at quarterly monitoring review meetings. The approved programs are based on statistical tests designed to accept or reject a series of null hypotheses. Monitoring is carried out at essentially two levels, primary and contingency. The contingency level program will be implemented whenever primary monitoring indicates a rate of change greater than would be considered a natural trend as defined by baseline conditions. Data gathered are compiled by the lessees and reported to the OSO semiannually. Yearly, the lessees analyze the monitoring data and report these findings, together with trends and interrelationships, as major parts of their Annual Operations/Progress Report to the OSO.

D. Reclamation

The oil shale leases contain specific stipulations for reclamation and revegetation of disturbed areas. The approved DDP includes plans, schedules, and methodology for reclamation that meet federal, state, and local regulations. Specifically, the lessee must reclaim all affected lands to a usable and productive condition consistent with predisturbed and adjacent land uses. Steps must be taken at all times to control erosion. Within ten years of DDP approval, lessees must demonstrate the ability to reclaim disturbed areas. In cooperation with private, federal, and state research groups, the lessees are carrying out extensive revegetation experiments. Experimental programs are evaluating plant species' suitability, planting times, mulching and topsoil requirements, the effect of toxic leachates, water harvesting, erosion control, seeding mixtures, mycorrhiza inoculation of soils and seeds, influence of slope and aspects, use of fertilizers, and need for temporary irrigation.

E. Tract Activities

1. Review and Approval

All activities on the tracts (exploration, development, monitoring, reclamation, and subsequent changes or revisions) must be approved by the OSO prior to implementation. OSO staff findings, requests for additional information, and recommendations for approval are recorded on evaluation forms. These become part of the permanent record of the review and decision process. During the review of DDPs or major modifications, public hearings are held. The Oil Shale Environmental Advisory Panel (OSEAP) and other public agencies are consulted.

Review and approval of routine activities on each tract are handled in a less formal manner. The OSO technical staff may meet with the lessees' technical staff to clarify technical issues and resolve problems. In all cases, OSO approval of any activity on tract, along with specific conditions or requirements of approval, is transmitted in writing to the lessee.

2. Suspension of Operations

To ensure compliance with lease terms and adherence to approved DDPs, and to prevent immediate danger to life or irreparable damage to property or the environment, the OSO may suspend operations on the lease tracts. During the suspension period, the lessee must complete specific corrective action. To date, this authority has been used only infrequently and applied to limited aspects of tract development.

The lessee may request suspension of the lease terms for resource conservation, legal, or environmental constraints. This option was exercised on November 1, 1976. Development of the four tracts could not proceed because of constraints on the use of off-tract land, unexpectedly low resource recovery, and conflict with Clean Air Act (Prevention of Significant Deterioration). Lessees were granted a one-year suspension of the diligence and bonus payment requirements. The C-a and C-b lessees prepared revised DDPs for Modified In Situ (MIS) development on each tract. This change increased resource recovery from Tract C-b and obviated the requirement for off-tract acreage for waste disposal and facilities siting near Tract C-a. Legal constraints under the Clean Air Act were also resolved.

Lease terms and requirements for Utah tracts (U-a and U-b) were suspended by court order in mid-1977 pending litigation over title to the tracts U-a and U-b. The lessees submitted a revised DDP on September 1, 1981. The Oil Shale Office will make a decision on this DDP when the injunction against the Department of Interior is lifted.

3. Diligence

The lease requires each lessee to diligently proceed with orderly development of the tracts and to attain production as early as possible. As an incentive, a minimum royalty, based on an escalating production rate, is required in the sixth and each succeeding lease year. All development work on the lease tracts is regularly inspected to ensure due diligence and adherence to approved DDPs.

4. Bonus and Royalty Offset

Section 4 of the lease requires payment of the bonus bid in five equal installments. As incentive for diligent development, the lessee may offset the fourth and fifth bonus installments by direct expenditures for tract development. As further incentive, the minimum royalty due in the sixth through the tenth lease years may be offset by expenditures related to development of the tract, if they were not credited against the bonus installments. Table 2 summarizes the bonus bid and royalties paid and offset to date. As of December 1981, a total of \$153,636,773.25 in bonus offsets had been

approved for the Colorado tracts. The \$22.4 million in excess of the amount required for the last two bonus installments will be credited against minimum royalty requirements or will be used to cover credits denied as a result of an audit. Over \$196 million have been paid by the Colorado lessees in the first three bonus payments. Thirty-seven and one-half percent of this amount has been returned to the State for use as impact funding assistance to affected communities. All monies for the Utah tracts are being held in escrow pending settlement of the State in-lieu land selection case.

If a lease has actual production in the sixth or succeeding lease year, the lessee cannot credit expenditures against the first \$10,000 of minimum royalty due for that year. Since Tract C-a had production during 1980 and 1981, a royalty of \$7,455 was paid to the government 1980 (\$10,000 less advance rental of \$2,545) and an additional royalty of approximately \$8,980 will be paid for production in 1981.

Table 2. Bonus Bid Payments and Offsets
as of December 1981

Lease	Amount Bid for lease	Amount of Bid Paid	Approved Offsets	Royalty Paid
C-a	\$210,305,600.00	\$126,183,360.00	\$104,193,940.00 ^{1/}	\$7,455.00
C-b	117,788,000.36	70,672,800.21	49,442,833.25	<u>4/</u>
U-a	75,596,800.00	45,358,080.00 ^{2/}	-- ^{3/}	<u>4/</u>
U-b	45,107,200.00	27,064,320.00	--	<u>4/</u>
Total	\$448,797,600.36	\$269,278,560.21	\$153,636,773.25	\$7,455.00

- 1/ While totals for "bid paid" and "offset" exceed the "amount bid for lease," only the amount of offset equalling the last two bid payments can be credited. The excess will be used to cover credit denied during audit or can be applied against minimum production royalties due during the sixth through the tenth lease years.
- 2/ Bonus bid payments from the Utah tracts are being held in escrow.
- 3/ Application for bid offsets have not been received from the Utah lessees because of lease suspension under court injunction pending settlement of state in-lieu land selection suit.
- 4/ No production has occurred on Tracts C-b, U-a, or U-b.

5. Inspections and Enforcement

Section 15 of the oil shale lease authorizes official representatives of the Department to conduct inspections and investigations of the leased lands at any reasonable time. The OSO conducts frequent inspections to ensure that lessee has complied with lease terms, approved DDPs, special stipulations, and applicable regulations. Ordinarily, an inspection will fall under one of the following four categories:

- Construction - activities such as road construction, earth fill and excavation, construction of surface facilities, etc.
- Mining - mine excavation, ventilation, gas monitoring, resource conservation, etc.
- Environmental - air and water quality and pollution control, waste disposal, revegetation, fish and wildlife management, etc.
- Processing - shale oil production and processing

An inspection is usually performed without prior notice to the lessee; however, notice may be given if specific personnel are required to be present or special arrangements are needed. Inspections are generally conducted on a weekly basis; staff specialists may conduct more frequent inspections.

An inspection manual written by the OSO documents the authority, procedures, and responsibilities for conducting inspections. In the event that a violation or item of concern is found during the inspection, it is verbally discussed with the lessee and the appropriate OSO technical staff to determine proper mitigative measures. All inspections are documented with a written inspection report listing all concerns and corrective actions.

6. Bonding

Section 9 of the Oil Shale Lease requires a \$20,000 minimum bond to ensure compliance with lease provisions. The amount of the bond is computed by a two-part formula: First, \$2,000 for each acre of leased land that would be used for mining operations or for disposal of processed shale; and second, \$500 for each acre affected by other operations on each tract. Bonds are renewed at three year intervals in an amount to be determined by the lessor to provide for reclamation and restoration of disturbed lands.

At the present time there is a \$1,000,000 bond on the C-b tract and \$6,000,000 for the C-a tract. These bonds are based on 1981 dollars and cover all costs to reclaim lands affected by activities described in the current DDPs.

III. THE OIL SHALE OFFICE

The Oil Shale Office (part of the Minerals Management Service [MMS]) is the Department of Interior's legal representative and agent for the administration of the POSLP and enforcement of the lease terms. Management responsibilities of the OSO are:

- Supervision and inspection of on-tract activities are conducted in accordance with lease terms, applicable regulations, and experience gained.
- Implementation of the DDP is continuously evaluated to ensure that knowledge and experience is applied to oil shale development. More than 157 changes or revisions were approved during the exploration or baseline and development phases of the POSLP, including three revisions of the environmental stipulations.
- Compilation and analysis of information from the leased tracts to assist in Departmental decisions on oil shale policy and leasing. OSO has reviewed nearly 400,000 pages of environmental and development data.
- Continuing development and implementation of management expertise needed for lease supervision. This means completing management guidelines and environmental analyses, conducting public hearings, acting on 564 bonus credit applications, actively participating at OSEAP meetings, and conducting 500 coordination meetings with the lessees.

For each lease, the OSO has the following duties:

- Approval of all exploration and environmental monitoring plans, DDP's, and related changes thereto;
- Evaluation of all actions, programs, and reports submitted by the lessees;
- Determination of lessees' compliance with lease terms, development plans, and applicable laws and regulations;
- Revision of ongoing programs to incorporate information gathered during development and the changing regulatory requirements; and
- Revision of Oil Shale Lease Environmental Stipulations in accordance with environmental data gathered and changes in environmental science and management.

The POSLP is a complex program. Technical, scientific, and management skills are needed from many disciplines. Thus, the staff of the OSO includes hydrologists, a meteorologist, an air quality specialist, mining and chemical engineers, wildlife, soil and reclamation scientists, and geologists.

The OSO operates on a team approach with a tract coordinator for each tract. Staff personnel function in a regulatory capacity for lease operations and,

equally important, in a coordination/liaison role, they bring their technical expertise to a particular aspect of tract administration. The OSO's environmental management task is aided by the Department of Interior's Oil Shale Environmental Advisory Panel. The OSO's staff and management structure are shown in Figure 3.

Further, the OSO operates on a Management by Objective (MBO) system. It is designed to act on exceptions to approved plans. All major decisions, reviews, and meetings are tracked by the MBO system. It is updated biweekly and all matters receive consideration in a timely manner. The MBO system is depicted on an activity control board used to guide planning meetings.

The OSO is the focal point for information on and technical expertise in oil shale development. The OSO staff prepares scientific or technical articles for professional journals and frequently presents lectures on oil shale geology, environmental management, and process and mining techniques. OSO staff belongs to the Piceance Basin Ground Water Advisory Committee, the EPA Oil Shale Work Group (associate member), the Water and Power Resources Service (formerly Bureau of Reclamation), Upper Colorado Resources Study Group, and working groups to evaluate air and water data from the Paraho operations.

An important contribution of the OSO to oil shale science is "A Method of Approximating Material and Energy Balances from MIS Retortings." This computer program, written by Lawrence K. Barker, estimates energy, elemental, and chemical mass balances during MIS retorting. This gives an estimate of retort operating performance and efficiencies; it allows the OSO to evaluate royalty payments made by the lessee. With slight modifications, the programs could be applied to other retorting technologies and to oil shales containing saline minerals (dawsonite and nacrolite).

By the end of 1981 the OSO had reviewed 263 applications for proposed oil and gas wells located on federal lands withdrawn for oil shale. The OSO makes on-site inspections of all wells within one mile of the lease tracts. It also assists the BLM District Manager and the USGS Oil and Gas Supervisor in preparing environmental analyses of oil and gas wells that may affect development of oil shales. In 1979, the Area Oil and Gas Supervisor and the Oil Shale Office developed casing and cementing requirements for all oil and gas drilling in the Piceance Creek Basin. These requirements were necessary to protect oil shale resources and ground water aquifers.

The OSO reviews and archives all reports generated by the lessees. These include periodic socioeconomic assessments, annual development and environmental monitoring analyses, bonus offset applications, engineering studies, permit applications, and plan modifications. Other agencies (EPA, Mine Safety and Health Administration, DOE, and state natural resource and mining divisions) routinely submit inspection reports. These reports are reviewed by the OSO. OSO assessments of major changes in development plans are summarized and compiled into decision documents. These and other reviews are used by the Deputy Minerals Manager-Oil Shale to administer the POSLP, development management expertise, act on plans and modifications, and answer inquiries from the public and government agencies. All documents and formal decisions are public, unless they contain proprietary economic, resource, or process information.

Table 3 below summarizes the major administrative actions taken by the OSO since 1976.

Table 3. Major Administrative and Enforcement Actions of the OSO

	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
New and modified exploration and mining plans (approved)	0	38	6	22	1	1
Miscellaneous approvals	<u>a/</u>	<u>a/</u>	50	31	32	47
Inspections <u>b/</u>	58	97	104	100	86	102
Environmental Analyses	3	3	2	1	0	3
Preparation of <u>Federal Register Notices</u>	3	3	9	0	3	2
Public Hearings <u>c/</u>	15	18	9	3	2	8
Bonus Credit Actions	<u>e/</u>	<u>e/</u>	163	401	0	2
General Meetings and Tours <u>d/</u>	216	264	317	231	277	288
Review of Application for Permit to Drill	<u>f/</u>	<u>f/</u>	<u>f/</u>	124	167	263

a/ Original development plans were approved in late 1977.

b/ Any one inspection may include up to four separate parts for environment, mining, construction, and processing.

c/ Includes 34 OSEAP meetings.

d/ Includes public meetings, tract coordination, conferences, symposia, presentations, and tours.

e/ No bonus credit applications could be accepted until development plans were approved.

f/ Cooperative review of APDs with MMS-Oil and Gas went into effect in 1979.

DEPUTY CONSERVATION MANAGER - OIL SHALE
Peter A. Rutledge

SENIOR STAFF ASSISTANT
James W. Hager

ADMINISTRATION

Administrative Technician
Barbara Dillard

SECRETARIAL

Secretary (Supervisory) - Donna Hause
Clerk-Steno - Judith B. Hopper
Clerk-Typist - Wava I. Russell
Clerk-Typist - Vacant

EXTRACTION

Senior Mining
Engineer,
John E. Miley

Mining Engineer,
Randy Heuscher

PROCESSING

Chemist,
Don Johnson

HYDROLOGY

Hydrologist,
Glen A. Miller

Hydrologist,
Michael Deneen

ATMOSPHERIC SCIENCES

Environmental Scientist
(Meteorologist)
Roger A. Tucker

Environmental Scientist
(Air Quality),
Lee Stevens

BIOLOGICAL SCIENCES

Environmental Scientist
(Wildlife), Robert L. Elderkin, Jr.

Environmental Scientist
(Reclamation), David Oberwager

Biologist, Donald R. Dietz
(USF&WS)

GEOLOGY

Environmental Scientist
(Geology), Eric G. Hoffman

Geologist, James Rush

DATA MANAGEMENT

Mathematical Statistician,
(Vacant)

Computer Specialist,
Joan Czarnecki

TRACT COORDINATION

(collateral duty)
R. L. Elderkin, Jr. - C-a

Eric G. Hoffman - C-b

Roger A. Tucker - Ua/Ub

Figure 2
Organization Chart of the Oil Shale Office
December 1981

The OSO archives all documents relating to tract activities and correspondence between the lessees, EPA, MSHA, DOE, and other agencies. Documents are coded for input into the OSO automated document library. At any given time, any document on a particular subject may be located in the file. Approximately 2305 items were archived in 1981. All documents, reviews, correspondence, and decisions are public, unless they contain proprietary economic, resource, or process information.

In 1980, the OSO expanded its use of ADP equipment in processing data, documents, and in systematizing office procedures. The automated document library (OSMIS) program file and bonus offsets were revised and updated. A procedure was developed to edit revisions to the Prototype Oil Shale Lease. This allows editing of revisions by printing the original version, any modifications, and comments on any changes.

All biological and environmental data collected by the lessees are stored on magnetic tapes and have been processed for statistical use. A description of all formats for data files is available from the OSO.

A program was written to input the budget expenditures and print out the necessary forms required by Central Region on a monthly basis.

Time and attendance records for the Western Slope Minerals Management Service are maintained by the OSO ADP facility. Financial Management reports are prepared for the OSO, Oil and Gas, Mining, and Resource Evaluation offices by the OSO. The Water Resources Division uses the OSO computer facility to run WATSTOR programs. OSO ADP facility allows the Oil and Gas, Mining, Resource Evaluation offices, and OSO to access the financial business software developed by the Central Region.

IV. TRACT STATUS AND DEVELOPMENT

A. Rio Blanco Oil Shale Company - Tract C-a

Tract C-a is leased to the Rio Blanco Oil Shale Company (RBOSC), a general partnership of Gulf Oil Corp. and Standard Oil Company of Indiana (AMOCO). A complete chronology of activities on Tract C-a is contained in Appendix A. Appendix B contains the legal description of the lease tract. This section of the OSO Management Report summarizes tract development to date and describes the direction which future development will take towards commercial production.

1. MIS Retorting at C-a

Modified in-situ (MIS) retorting and underground mining with surface retorting is the approved development plan. This initial Modular Development Phase (MDP) includes operation of two MIS retorts which were burned by the end of 1981. Blast holes for rubblization were drilled from the surface, loaded with explosives, and detonated in stages from the bottom upward. During initial blasting, shale rubble equal to 20-40% of the final retort volume was withdrawn from the bottom of the retort. Hoisted to the surface by a skip operating in the Service/Production Shaft, this shale was stockpiled for future surface retorting. Retort rubblization was continued to fill all but a narrow attic at the top of the planned retort chamber.

Each retort was ignited with RBOSC's own specially-designed downhole burners. Because of the uniform rubble distribution and size produced by RBOSC's blasting technique, burn rates of more than two feet per day are possible and channeling of the burn front is minimized. Air and steam were supplied through the blast holes to sustain and control the retorting process.

2. Retort "0"

MIS Retort "0" on C-a was the beginning of RBOSC's MIS field processing studies and produced the first oil from the POSLP. This 166' high, 30' square retort was ignited October 13, 1980. It produced 1,876 barrels of oil and condensable hydrocarbon vapors from 4,904 tons of shale. Recovery of the potential resource from the rubble within the retort was nearly 68%, based on Fischer Assay of the available raw shale. The retort contained a minimum of instrumentation for evaluating the burn. Rubblization appeared to be effective and flow tests prior to the burn indicated minimal problems with flow and burn channelization. Retort "0" produced more H₂S than had been anticipated. The source of this excess H₂S is thought to be primarily pyrite. The off-gas was incinerated and scrubbed, hence essentially no H₂S was released to the atmosphere.

The Department of Energy's Oil Shale Task Force (OSTF) ran detailed analyses on sulfur species generated by the burn of Retort "0." Their preliminary report showed the retort off-gas contained H₂S of nearly 4% (by volume). Their results also demonstrated that a significant fraction of the sulfur in the off-gas, varying from 0.9% to 4.2% during periods of measurement, can exist in forms other than H₂S under conditions of this retort burn such as carbonyl sulfide, carbon disulfide, methyl mercaptan, thiopene, sulfur dioxide, and methyl thiophene.

Retort water from Retort "0" was produced in a greater volume (about 31,000 bbls) than expected and was of better quality than expected. Quench water, steam for processing, formation water influx, and other sources contributed to this excess water production and the resultant dilution of combustion-produced process water.

3. Retort "1"

MIS Retort "1" was ignited in mid-June 1981. Retort "1" is closer to commercial size (400' h x 60' square) and produced 24,440 barrels of shale oil and condensable vapors - 68% recovery of the potential oil from rubblized shale contained in the retort, based upon Fischer Assay of the raw shale. Retort "1" instrumentation provided information on retort temperatures, differential pressure (including differential pressures in various zones of the retort), gas flow rates, inlet and exit temperatures, gas composition, gas Btu content, and other data. Although much of the operational data is proprietary, some information is available to the general public.

Tests on Retort "1", before ignition, generated considerable concern about leakage from the retort into the mine. RBOSC's initial efforts to seal the leaks were minimally successful. Additional attempts to seal the retort helped and finally the instrumentation shaft was slightly pressurized with inert gas to minimize oxygen influx into the retort from the surrounding area. Retort "1" ignition and the burn were conducted without serious problems from the remaining leaks around the retort.

Retort "1" was operated in several air and steam injection modes to determine MIS operational parameters. These modes included air injection only, air-steam injection, and steam-inert gas injection. These various injection modes were used to test retort burn control schemes and to vary off-gas quality. Steam injection greatly enhances off-gas quality by the water-gas reaction while contributing to burn control by limiting maximum retorting temperatures. Air-steam retorting produced off-gas of about 80 to 90 Btu while air-only injection produces 60 to 70 Btu off-gas.

Initially, Retort "1" burn rate exceeded the rate for Retort "0", but surface equipment and control problems slowed the overall burn rate to slightly faster than two feet per day. The major surface equipment problem was corrosion of the scrubber stack caused by sulfuric acid generated in the stack. This temporary scrubber stack is steel, lined with a petroleum-based mastic. Field welding necessary for construction of the 200' high stack damaged the mastic liner and allowed sulfuric acid contact with the metal stack. A commercial operation would incorporate a stack designed to resist the corrosive attack by sulfuric acid and other stack vapors.

Retort "1" produced less H₂S than Retort "0" even though the retorts are probably no more than 100' apart. Maximum H₂S in the Retort "1" off-gas was only 1.2% by volume. The reason for this difference in retort performance is under investigation, but less pyrite in the zone contributing the rubblized material of Retort "1" is suspected to explain the difference in H₂S production.

The Oil Shale Task Force made sulfur species determinations on off-gas from Retort "1". These data will be compiled and reported at a later date.

Other contributions by the Oil Shale Task Force are discussed in another section of this report.

Retort "1" cooling and abandonment procedures are presently under discussion. There are two schools of thought on this subject. The first is to minimize the cooling period by using water to flush the retort. The second is to save the retort for additional post burn studies by not using a water flush step. Because the burn was highly successful and production of oil was very high, the spent retort would provide essential data for commercial retort abandonment procedures. Water cooling would minimize the value of these studies. However, without water cooling, post burn studies could not be conducted for a long time because of the slow cooling rate for the retort.

4. Special Problems at C-a

Early in 1981, RBOSC discovered that their raw shale storage pile had some "hot" spots. Initial temperature measurements showed temperatures to about 150°F. Some of the hot section of the pile was dozed out and cooled. In addition, holes were drilled into the rest of the pile and thermocouples were inserted to various levels in the storage pile. The thermocouples equilibrated to about 115°F in a few days and then began to show a slow cooling trend. The combination of wet weather, high shale pyrite content, oil shale fines and air circulation through a particular section of the pile were believed to encourage the exothermic oxidation of pyrite and the subsequent shale pile heating.

Sulfur content of Green River Formation oil shales is usually quite consistent ranging from 1.25 to 1.5% in the Mahogany Zone in the vicinity of Tract C-a. Sulfur occurs as both an organic constituent and as part of the complex mineral matrix. Organic sulfur content correlates with variations in total organic content of the oil shale. Pyrite that was formed as a part of the original shale deposit (primary deposition) also occurs in small and rather uniform quantities - about 1%. Unfortunately, pyrite also appears to occur as a secondary depositional mineral. Secondary pyrite may have been deposited after the oil shale was fractured and faulted. Little is known about the extent of pyrite deposition on the C-a Tract and throughout the Green River Formation. Apparently core samples ineffectively represent the extent of secondary pyrite deposition. Numerous faults and fractures occur on the C-a Tract. The raw shales from Retort "0" may have had higher concentrations of secondary pyrite than raw shales from Retort "1". The difference in pyrite content may be related to the density and number of fractures. Further research is needed to predict the distribution of sulfur in Green River oil shales.

Pyrite has been the culprit behind two problems at the C-a Tract - shale pile heating and sulfuric acid corrosion of the stack, although pyrite is probably not solely responsible for the latter. Although the stack corrosion problem can be easily controlled in a commercial operation. H₂S production from pyrite will dictate some design parameters for off-gas cleanup. Accurate information on pyrite occurrences, particularly with regard to secondary deposition, throughout the Green River Formation would be useful in developing an oil shale industry.

5. Future Plans with Lurgi-Ruhrgas Retort

The burning of Retort "1", a scale-up toward commercial-sized retorts, concludes RBOSC's modified in situ program at C-a. In the next phase of development, RBOSC will build and test a 1- to 5-ton-per-day Lurgi-Ruhrgas retort. This surface retort was selected for several reasons, primarily that high oil recovery is combined with high operating efficiency. In the Lurgi retort, processed shale is the heat transfer medium. The hot, processed shale is mixed with incoming, raw shale to pyrolyze the kerogen. The carbon residue on the retorted shale is burned in a pneumatic lift pipe to generate almost all heat required for the process. Since carbon combustion of the processed shale occurs in the lift pipe and is isolated from the retort, the Lurgi process gas contains little nitrogen or carbon dioxide and results in a high-Btu gas that can be used in the process or to generate electricity. The carbon-free, processed shale has cement-like properties when wetted which may simplify disposal procedures for the large volume of waste material. Finally, the Lurgi lift pipe is designed to absorb sulfur from the gas stream onto the calcined processed shale generated in the carbon combustion process.

Initially, C-a planned an open pit mine with surface retorts and disposal of processed shale on off-tract lands. This original plan was abandoned because the U.S. Department of Interior did not have authority to grant use of off-tract lands. Because of the restriction on off-tract disposal, the lessees prepared a MIS development plan. Recently the plan for an open pit mine was revived when the lessees of C-a obtained land from the Colorado Division of Wildlife for limited off-site disposal suitable for a demonstration size plant, but not large enough to support a commercial operation. Legislation to provide off-site federal land for surface plants and storage of waste materials from a commercial shale operation has been passed by the House of Representatives and is pending before the full Senate.

Further information on Tract C-a, including detailed monitoring reports, is available in Grand Junction, Colorado. Additional information on Retorts "0" and "1" will become available after the wealth of collected data is compiled and analyzed. On file at the OSO are DDPs and Modular Development Plans, annual and quarterly reports, and raw data files and tapes from Tract C-a. These reports are available for public inspection during regular business hours with the exclusion of certain proprietary economic, resource, and process data.

B. Cathedral Bluffs Shale Oil Company - Tract C-b

Federal Tract C-b is leased to the Cathedral Bluffs Shale Oil Company (C.B.), a partnership of Occidental Oil Shale, Inc. (operator), and Tenneco Shale Oil Co. (partner). A chronology of major activities that have occurred on tract is contained in Appendix A. The legal description of the lease tract is presented in Appendix B.

The approved Detailed Development Plan (DDP) for Tract C-b outlines a schedule for commercialization by modified in situ (MIS) methods from multi-level mine workings accessed by large diameter shafts. Oil shale will be mined on each mine level, hoisted to the surface, and retorted or temporarily stockpiled. Processed shale will be permanently disposed of in gulches incising the eastern half of the tract area, covered with native soil, and revegetated.

Since 1978, major activities on-tract have centered about the construction of commercial-scale headframes and the sinking of three large diameter mine shafts. Excavation of the 15-foot diameter Ventilation/Escape Shaft began in May 1978, and was completed to design depth of 1,617 feet on August 27, 1981. During excavation, the shaft was ring drilled and stage-grouted throughout its entire depth in advance of blasting. Despite this effort, ground water inflow rapidly increased below the 1,200 foot level to more than 900 gpm. Peak inflow was 1,070 gpm from brecciated or vuggy (broken) ground near the top of the "A" groove. Several methane gas ignitions occurred near the 960 foot level resulting in the shaft being declared "gassy" by the Mine Health and Safety Administration on January 2, 1980. A methane and water blowout occurred at the 1,255 foot level on October 8, 1980, temporarily flooding the shaft bottom. During latter stages of sinking, methane readings averaged .4 percent in station level headings. Five mine level stations were stubbed out and concreted during sinking. After the last of the shaft steel and concrete were placed in the Lower Void Level station, the shaft was temporarily flooded to reduce the amount of mine water that had to be treated and disposed of. The shaft will be dewatered when needed for further mine development. In December 1981, water level in the shaft had risen to within 424 feet of the collar which has been left open to vent methane. The collar area is secured by an 8-foot high safety fence.

Sinking for the 34-foot diameter Service Shaft began in February 1978, and was completed to 1,757 feet on April 10, 1981. Ground water inflow increased to 280 gpm below 1100 feet and remained constant thereafter. Planned foregrouting of the shaft column was not needed. Methane concentrations were generally nil at all times. After shaft sinking was completed, the sinking galloway was modified and used to install permanent utility lines and fixed hoist guides. This work was completed by September 25, 1981. A 30-ton bridge crane was installed at the top of the 178-foot high concrete headframe. It is being used to place steel, concrete, and equipment on the several hoist and power control floors. The 1,500 h.p. (30,000 lb.) friction hoist motor and drum for the main 240-man cage have been installed. Two smaller 300 h.p. auxiliary hoists are nearly completed. Precast concrete utility tunnels have been placed from air locks on the headframe subcollar level to the subgrade levels of the adjacent electrical substation and the Operations/Changehouse. Cableways, ducting, and lighting are being installed throughout the headframe and tunnelways. The Service Shaft and headframe should be fully operational by the summer of 1982.

Sinking of the 29-foot diameter Production Shaft began in February 1978, and was completed to final depth of 1,867 feet on September 29, 1981. Ground water inflow increased when sinking penetrated the "A" groove 1,300 feet below collar and has remained fairly constant thereafter at 140 gpm. Planned grouting of the shaft column was not needed. Methane concentrations were generally nil. Shaft sinking was slowed significantly in early 1981 when incompetent, brecciated shale was encountered in a compaction flexure (stratigraphic fold) at the Lower Void Level. Extensive structural steel and concrete were required to stabilize the ground. The remainder of 1981 was needed to excavate the ore skip loading pockets and cleanout drift, set shaft steel, and install loading facilities and rope guides for the four ore skips. A 60-ton bridge crane was installed at the top of the 313-foot high concrete headframe. It is being used to set steel and pour concrete for the hoist and

power control floors. Sole plates for the two 9,500 h.p. friction hoists are being installed. Each hoist will pull two 52.5-ton capacity skips in balance. Foundations for reclaim conveyor feeder extensions at the bottoms of the two 800-ton headframe ore bins have been completed and trenching for the first hundred feet of the two raw shale conveyors is underway. Installation of electrical wiring and duct work is in progress throughout the headframe and connecting utility tunnels. The shaft and headframe should be fully operational by the summer of 1982.

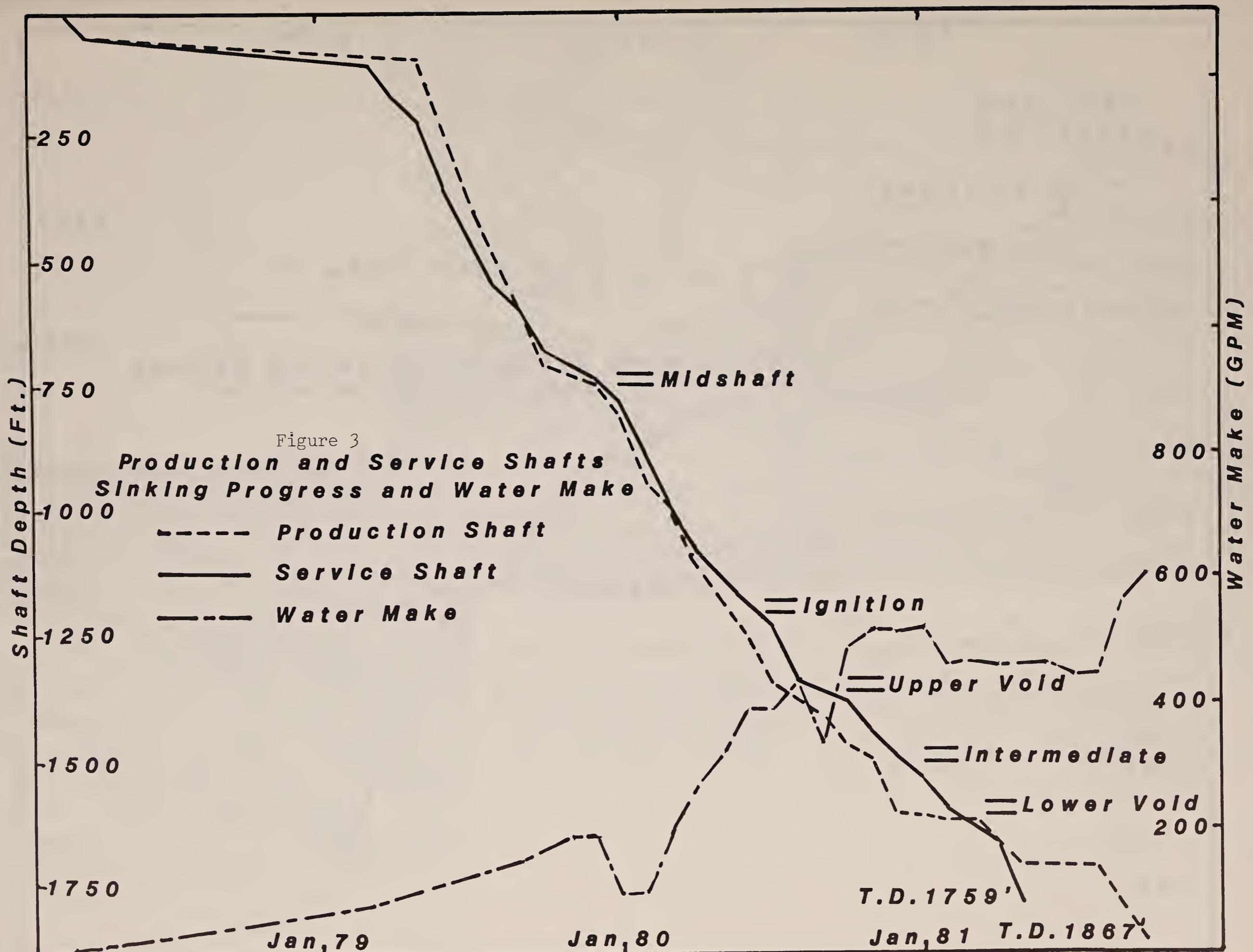
Ground water inflows were encountered during shaft sinking and station development. Inflow observations and pumping data suggest that the majority of the ground water (70-80%) was coming from below the ignition level. Comparison of water production curves from the V/E, Production, and Service Shafts with monitoring well behavior indicates that 70% of the combined shaft pumpage was coming from the V/E shaft from source areas generally NE of the tract. Curtailment of V/E shaft pumping, however, resulted in a steady increase in combined Service and Production Shaft pumping of 160 gpm. Below the Mahogany Zone, water inflow was minimal, confined largely to the "B" Groove. Figures 3 and 4 compare rates of shaft sinking and ground water inflows.

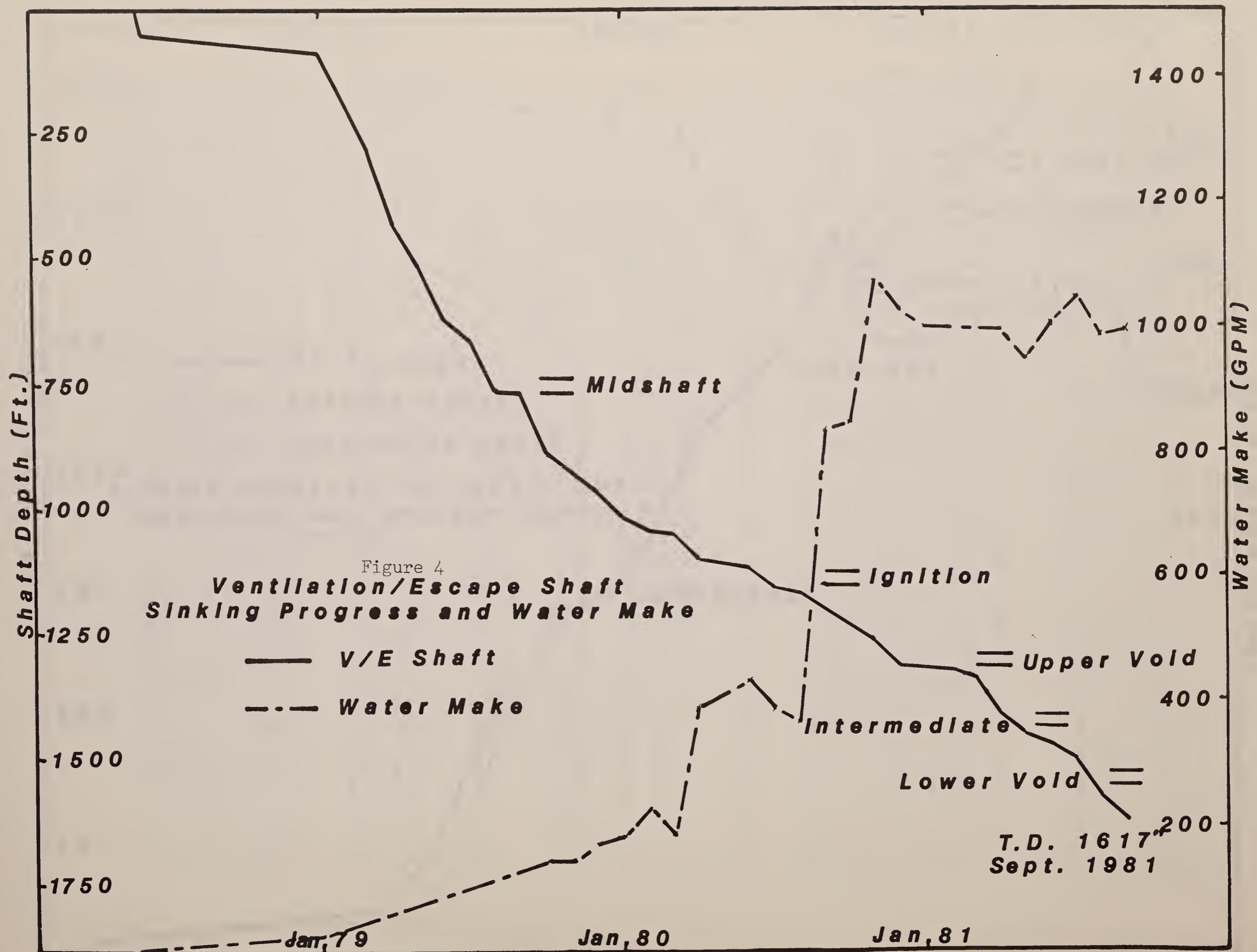
Mine support facilities completed since 1979 or currently under construction (shown in Figure 5) include:

1. 9,000 gallon-per-day sewage treatment plant;
2. Automatic acid and flocculent metering system for treatment of mine water prior to reinjection or release;
3. Enlargement of erosion control basins to meet 100-year storm runoff criteria;
4. One-half acre paved heli-pad and adjacent public relations trailer;
5. 15,680 square feet of additional temporary office space, laboratories, truck scale, and warehousing;
6. 138 KV powerline from Meeker;
7. 4-1/2 acres of electrical switchyards and substation;
8. Foundations for nearly two acres of permanent warehouses, shops, offices, and changeroom facilities.

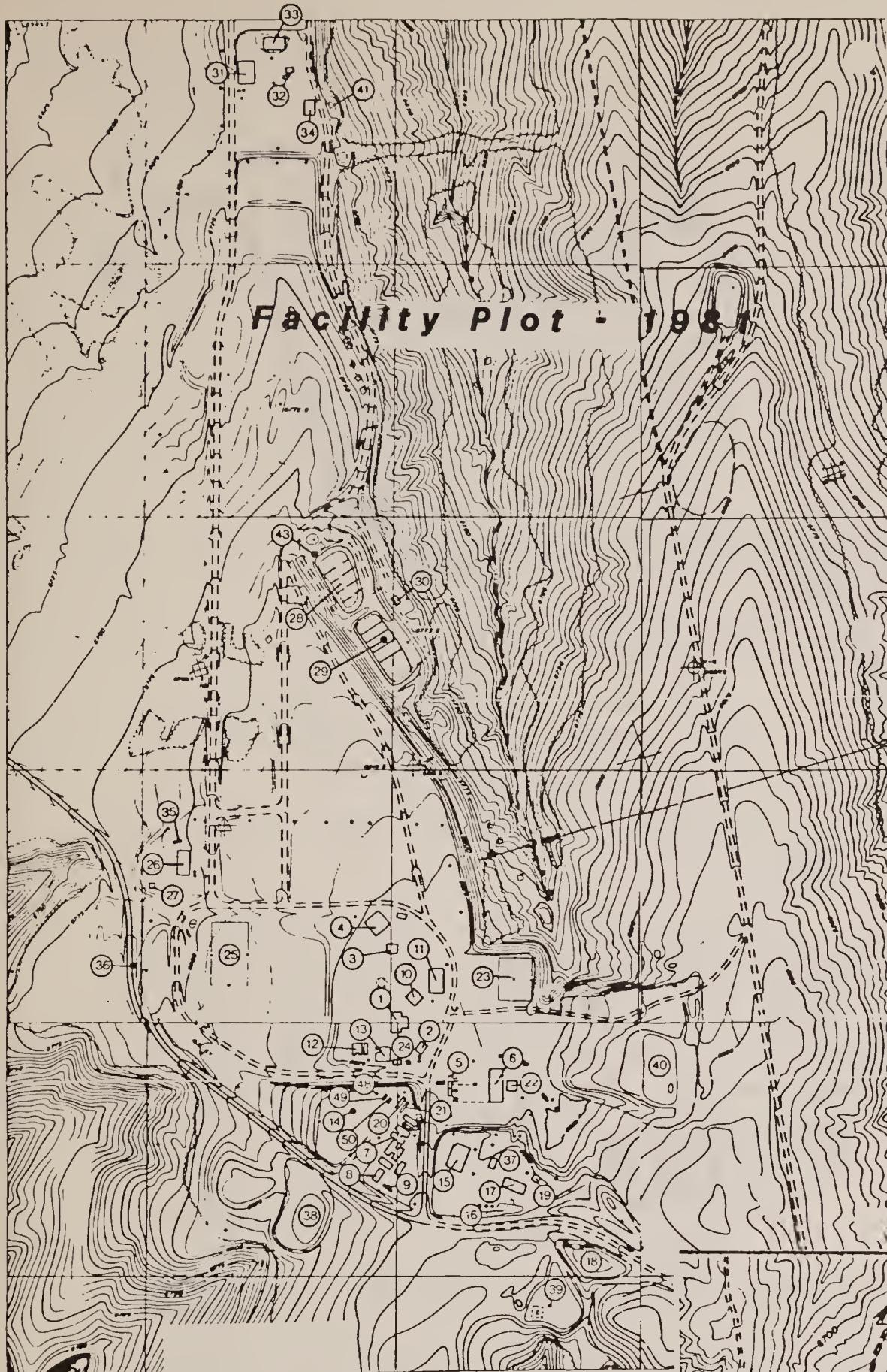
Construction of these and other facilities disturbed 15.8 acres in 1980 and nearly 25 acres in 1981. A summary of acreage disturbed and revegetated is presented in Table 4 and depicted in Figure 5. All areas except active construction sites, laydown yards, water treatment facilities and maintenance areas have been reseeded.

A 1,771-foot deep reinjection well was drilled adjacent to mine water Pond "C" in the SW part of the tract and successfully tested in a series of 30-day reinjection tests at flows up to 450 gpm. Since dewatering of the Ventilation/Escape Shaft was terminated, this well and its ancillary water filtering system have accepted all excess mine water which has increased to 465 gpm, reducing surface discharge to zero. Prior to this, approximately 35 million gallons per month of mine water were treated and discharged. This water has an average fluoride and ammonia concentration of 18 mg/l and 0.7 mg/l, respectively.





TRACT C-b



1. Production Headframe
2. Production Headframe
3. Service Headframe
4. Service Hoist
5. Cement Batch Plant
6. Cement Batch Plant Aggregate Storage
7. Office Complex (4 Trailers)
8. Emergency Vehicle Building
9. First Aid Trailer
10. Production Hoist
11. Gilbert Shop
12. Gilbert Offices
13. Dry
14. Parking Area
15. Warehouse
16. Fuel Storage Facilities
17. CGE Warehouse
18. Topsoil Storage Area
19. Fabrication Shop
20. Office Trailer
21. Office Trailer
22. General Service Contract Offices
23. Colorado Ute Switchyard
24. Winch
25. CGE Storage Area
26. Generator Building
27. Pump Repair Building
28. Pond A
29. Pond B
30. Pumphouse
31. V/E Hoist House
32. V/E Headframe
33. Gilbert Shop
34. Gilbert Dry
35. Fuel Storage
36. Paved Main Access Road
37. Generator
38. Rebar Storage Yard
39. Environmental Storage Building
40. Shale Disposal Area
41. Backwash Pit
42. Recreation Trailers
43. Acid Injection Building
44. Guard House
45. Truck Scale
46. Heliport
47. L'eau Claire Filter
48. Brass Shack
49. Hydro/Air Lab
50. Soils Lab

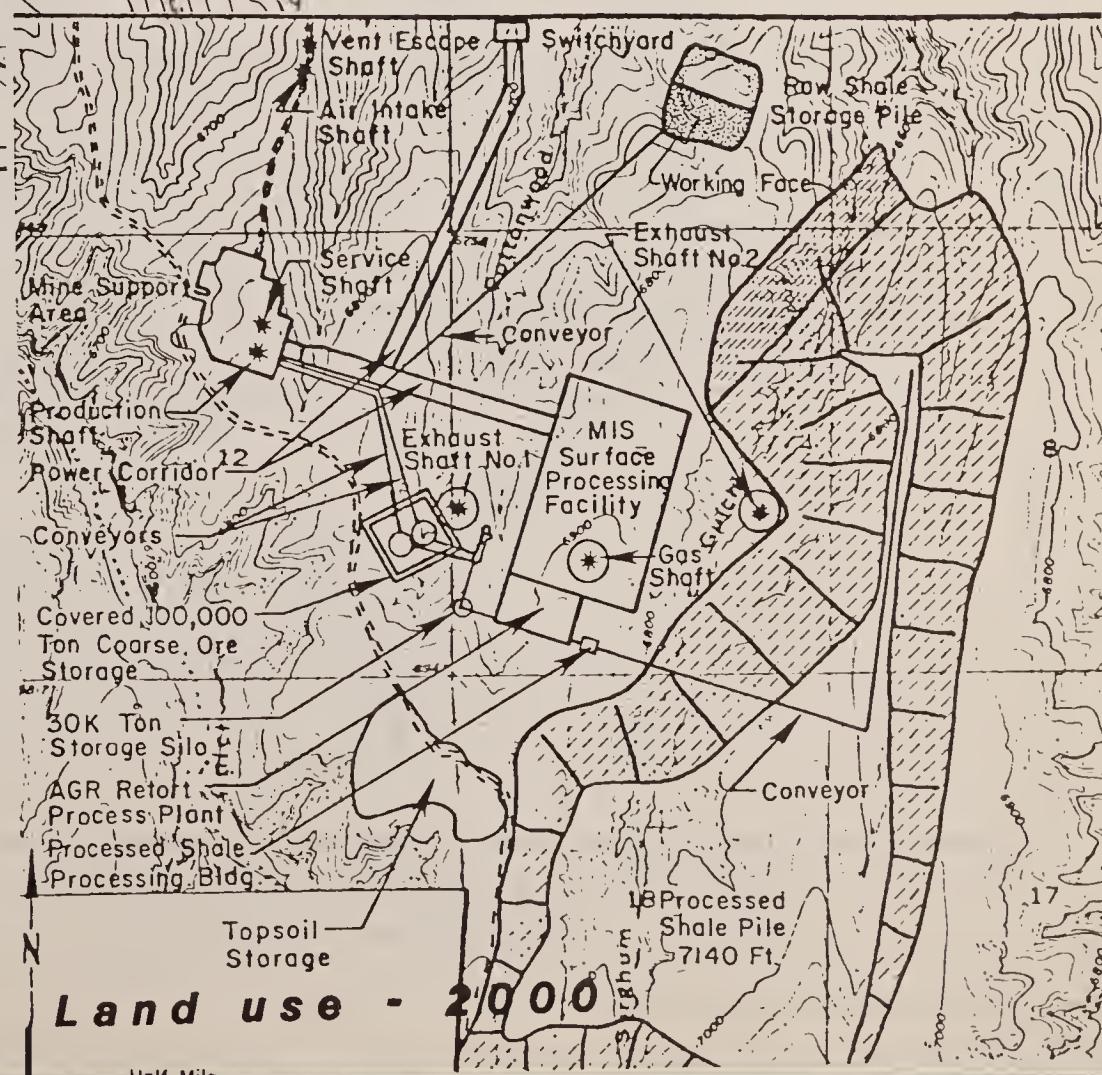


Figure 5 Facilities Plot,
Federal Lease Tract
C-b, 1981

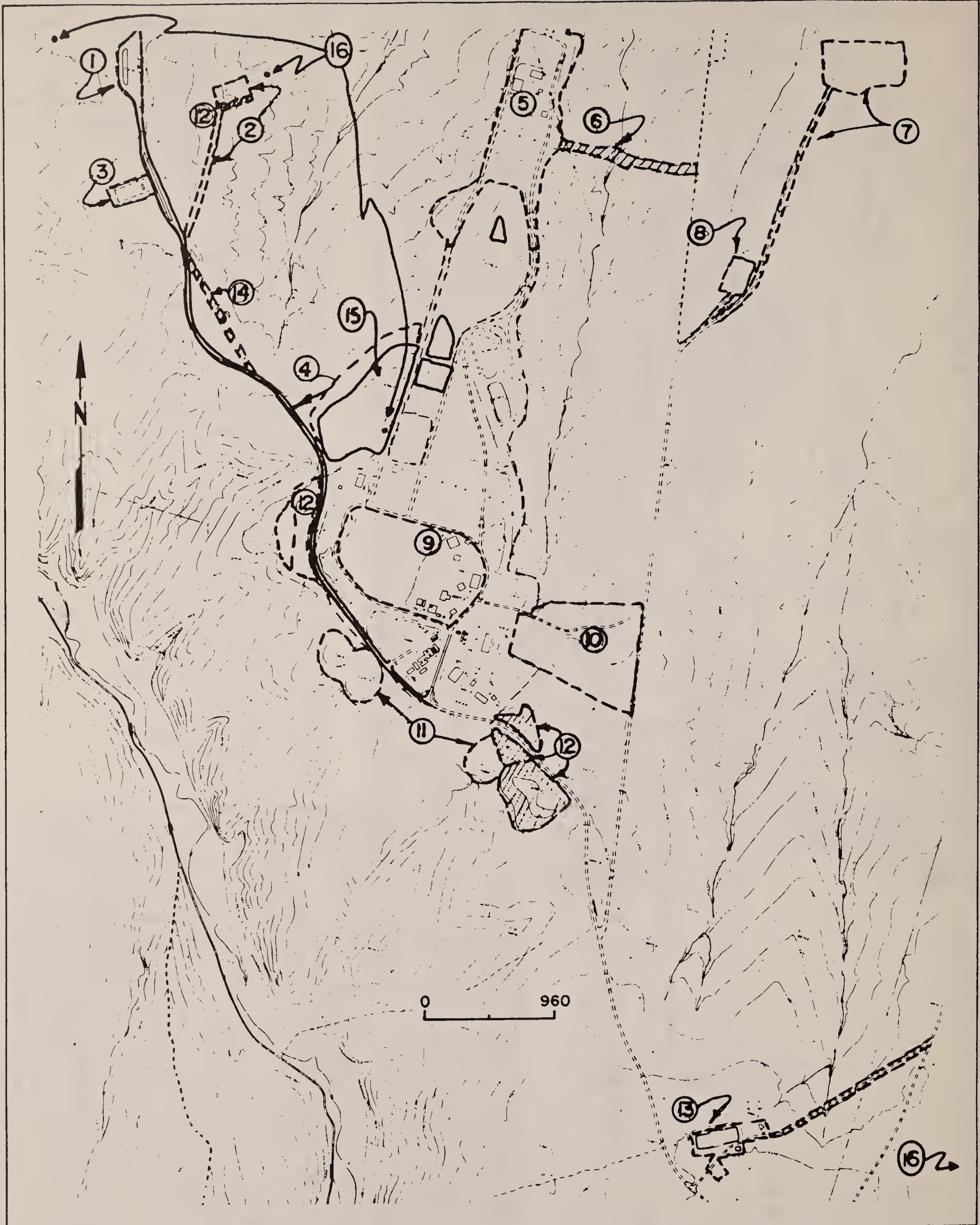


Figure 6 Areas Disturbed on Tract C-b (refer to Table 4 for description of numbered locations)

Significant actions related to ongoing development monitoring include:

1. Recompletion of 12 deep aquifer monitoring wells with permanent water level recorders;
2. Drilling a Unita aquifer monitoring well below the raw shale pile east of the Production Shaft;
3. Relocating gages in tributary drainages that carry runoff from the tract to Piceance Creek;
4. Installing a new stream gage on Piceance Creek just below the confluence of treated mine drainage discharge (Little Gardenhire Gulch);
5. Refitting and "fine tuning" the air quality/meteorology stations;
6. Conducting LANDSAT imagery/biomass correlation sampling;
7. Screening cattle and school age children in the vicinity of the tract for signs of fluorosis;
8. Conducting fish toxicological studies in varying concentrations of mine water;
9. Operating raw shale leachate collectors;
10. Radio collaring a number of mule deer fawns and adults to more accurately define migratory movement and predation.

Preliminary environmental monitoring findings are discussed in Part V of this report.

As of December 1981, 137 regulatory permits (other than construction) had been obtained or were in processing. These include 45 for air, 53 for water, 16 for land, 2 for RCRA, and 21 others. EPA agreed to consider supplemental modeling for above ground retorting in C.B.'s revised PSD application. Colorado State Water Court has been asked to consider a reservoir site in East Stewart Gulch. Colorado Mined Land Reclamation Board issued approval for disturbance of 120 additional acres between the Service and V/E Shafts for surface process facilities. Rio Blanco County Commissioners approved issuance of \$650 million in tax free, low interest IDB bonds to finance on-tract pollution control equipment.

The lessee had prepared a preliminary draft revision to the approved DDP for production of up to 117,000 barrels per day from combined MIS and surface retorting by the mid-1990's. A draft loan guarantee application to the Synthetic Fuel Corporation had also been prepared. On December 17, 1981, however, C.B. announced that recent engineering studies indicated that development could not proceed as planned due to unanticipated escalation in construction and operating costs. Tract and Grand Junction employment would be reduced from more than 528 to nearly in half by mid-1982, while development alternatives are reevaluated and a new development plan scoped out.

Table 4. Estimates of Disturbed and Revegetated Acreage*
(Tract C-b)

Disturbed Area	Disturbed			Revegetated		
	Before 1980*	During 1980	During 1981†	Before 1980*	During 1980	During 1981†
1) Guard House & Truck Scale Area	3.4					
2) Sewage Treatment Plant and Road			1.4			.4
3) Heliport & Public Relations Facility	0.6					
4) Main Access Road	23.5					
5) Ancillary Area (V/E Shaft)	17.2					
6) Proposed Dam Site (Little Gardenhire)	1.2				1.2	
7) Switchyard Area and Access Road			6.1			
8) Explosive Storage Area	1.8					
9) Mine Support Area ⁺	72.2			2.0		
10) Raw Shale Storage Area	6.0	5.0		2.0		
11) Rock Stockpile Areas	7.7					
12) Topsoil Stockpiles	5.5	3.3	4.0	5.5	3.3	4.0
13) Water Discharge and Application Area (Pond "C" Area)	3.7					
Irrigation System Pipelines	4.0			4.0		
14) Abandoned Access Road	10.0			10.0		
15) Water Treatment/Process Area			13.0			
16) Corehole and Rejection Drill Sites			3.5			3.5
 Totals	156.8	15.8	24.5	20.7	3.3	7.9

* Acreages revised from 1979 Annual Report based on aerial photos taken in 1980.

† On site estimates.

+ Includes temporary and permanent offices, warehouses, operations, and changehouses.

C. White River Shale Project (WRSP) - Tracts U-a and U-b

Tract U-a is jointly leased by Phillips Petroleum Company and Sunoco Energy Development Company. Tract U-b is leased by Sohio Shale Oil Company. The three lessees have formed the White River Shale Oil Corporation to jointly develop U-a and U-b as the WRSP. The legal description of Tracts U-a and U-b is contained in Appendix B.

Development of Tracts U-a and U-b has been delayed due to litigation stemming from Utah's statehood land selection rights (in-lieu lands) and prior, unvacated mining claims. In the former case, the U.S. District Court for Salt Lake City (Findings of Fact, Conclusion of Law, and Decree, June 8, 1976) favored Utah's position. The Court ruled that "indemnity selections" of in-lieu lands in Uintah County must be made acre-for-acre, rather than value-for-value, the Department of Interior's position under the Taylor Grazing Act. The U.S. Court of Appeals, Tenth Circuit (Denver), on August 8, 1979, supported Utah's claim to 157,225,990 acres (63,688.6 ha), which includes Federal Oil Shale Lease Tracts U-a and U-b. On December 5, 1979, the Justice Department appealed to the U.S. Supreme Court. The Supreme Court issued a 5-4 opinion on May 19, 1980. The Court upheld the Department of the Interior's position, reversed lower Court decisions, and ruled that the indemnity selection may be made value-for-value.

On May 18, 1977, the lessees of Tracts U-a and U-b filed suit against the Department of Interior. They sought an injunction to indefinitely suspend lease requirements for diligent development and bonus bid payments until conflicts with overlapping mining claims and state selection of lands were resolved. A hearing was held on June 3, 1977. On June 8, 1977, a preliminary injunction was granted (Civil No. C77-0165). It stated that "The Secretary of Interior and any of his agents or subordinates are enjoined from seeking to enforce the terms and conditions of [the] leases of Tracts U-a and U-b or any of the obligations...thereunder in any manner... during the pendency of this action."

Since June 8, 1977, the lessees of Tracts U-a and U-b have continued the baseline monitoring program. Data on air quality, biological resources, and hydrology have been collected.

1. Proposed Development

During 1981 the lessee prepared a Detailed Development Plan (DDP) for joint commercial development of the two Utah tracts. The plan was formally submitted to the Oil Shale Office on September 1, 1981. Public hearings were held in Vernal, Utah, on October 21, 1981, and in Salt Lake City, Utah, on October 28, 1981. The DDP and all the public comments have been reviewed by the Oil Shale Office. An approval action is expected in early February 1982, depending upon the lifting of the preliminary injunction.

The plan calls for commercial production of over 100,000 barrels of oil per stream day (BPSD) by 1993. Room-and-pillar underground mining and above ground retorting (AGR) will be used.

WRSP's DDP describes three phases of development to reach commercial production. In Phase I, mining and retorting will produce (1) information on ore body characteristics that cannot be determined by core drilling and (2) information on the retorting processes. In this phase, an average of 27,330 tons per stream day (TPSD) will be mined and processed in two above ground retorts to produce approximately 14,840 BPSD. An on-tract upgrading facility

will be used prior to transporting the synthetic crude oil off-tract by pipeline.

Phases II and III follow the same general plan as Phase I and increase net shale oil production to 56,875 and 106,300 BPSD, respectively. Mining will average 93,460 and 176,740 TPSD, respectively. At this production rate, oil shale resources of the tracts will be exhausted in 2007 A.D.

The lessees will use the Union B retort and the Superior retort in Phase I. The Tosco II process will be used after Phase I to process shale fines rejected by the other processes. The Union B process uses <2" to >1/4" size shale. This indirect-heated retort produces a high BTU gas. The Superior retort uses <4" shale for the direct-heated retort. It produces a low BTU gas. The TOSCO II retort produces high BTU gas. In Phase I, nearly 15,000 barrels of shale oil will be produced from the two retorts. In Phase III, over 100,000 barrels of shale oil will be produced per day.

Estimated capital and operating costs for each phase of the WRSP are summarized below.

Table 5. Estimated Capital and Operating Costs (a,b)

Phase	Incremental Capital Costs (Million \$)	Incremental Operating Costs (Million \$/yr)	Total Shale Oil Produced (c) (BPSD)
Phase I	661.8	75.5	14,840
Phase II	1,266.1	196.9	56,875
Phase III	1,364.4	333.9	106,300
Total	3,292.3	606.3	--

- (a) All costs are within an accuracy of 25 percent, 1981 dollars.
- (b) Estimates are based on conceptual design of the project plan as described in this Detailed Development Plan. Capital costs include owners' costs subsequent to 1981.
- (c) 328.5 days per year.

From: White River Shale Project, 1981 Detailed Development Plan.

A two-volume DDP, Preliminary and Final Baseline Report, and quarterly environmental monitoring reports from the WRSP are available for public inspection at the OSO.

V. ENVIRONMENTAL MANAGEMENT AND MONITORING

The POSLP lease requires the lessees to collect extensive data on the environment surrounding each tract and to measure changes in the environment since the start of development. Below are summaries of the monitoring programs in hydrology, air quality, biological resources, and scientific and cultural resources. Information is also provided on health and safety, socioeconomic changes related to the POSLP, reclamation plans, geology, and ecological interrelationships. Special emphasis has been given to environmental effect caused by tract development and activities. Further detailed information and raw data are available through the OSO.

A. Hydrology and Water Resources

The two Colorado tracts are located in the Piceance Creek Basin, a 900-square mile area of moderate relief drained to the north into the White River by Piceance and Yellow Creeks. Piceance Creek flows perennially throughout most of its course. Yellow Creek is ephemeral except for a few reaches. Corral Gulch and Stake Springs Draw drain Tract C-a into Yellow Creek; Tract C-b is drained into Piceance Creek via several short ephemeral tributaries and by the more persistent drainages of Willow Creek and Stewart Gulch.

Tracts U-a and U-b are in the northeast part of the Uinta Basin, along the south side of the White River. The tracts are drained by Evacuation Creek on the east and by Asphalt Creek on the west, both are major local tributaries of the White River. Southam Canyon and several smaller unnamed tributaries drain most of Tract U-a into the White River. Evacuation Creek is perennial across most of Tract U-b, while the other drainages are ephemeral.

The quantity and quality of surface and ground water are monitored at all Colorado tracts. Flow and quality of surface water is monitored upstream and downstream of the tracts by six stations at Tract C-a and by 14 stations at Tract C-b. On the Utah tracts, surface and ground waters were monitored during the baseline period at 14 gages and at more than 30 wells.

Flow and water quality of springs and seeps are monitored at six sites on or near Tract C-a and at nine sites around Tract C-b. Ground water levels and quality are monitored at 36 wells at Tract C-a and at 36 wells at Tract C-b.

1. Surface Water

At Tract C-a, ephemeral streams drain northeastward into the Yellow Creek system. Corral Gulch and its tributaries drain most of the tract. Natural flow in the gulch near the downstream (east) tract boundary ranged from about 260 to 630 acre-feet (3.2×10^5 to 7.8×10^5 m³) per year during the baseline period.

Mine water discharge from C-a to Corral Gulch, noted in the OSO 1979 report, was near zero during 1981. However, increased downstream flow in Corral Gulch and Yellow Creek continues because of the drainage of alluvium that was previously saturated with discharged mine water. The effects on big sagebrush of raised ground water levels in the alluvium along Corral Gulch

(noted in the OSO 1979 report) remains marked, a lush growth of grasses has appeared in the area of dead sagebrush.

At Tract C-b, several small ephemeral streams drain much of the tract directly into Piceance Creek. The average annual flow in Piceance Creek below Tract C-b was about 11,500 acre-feet ($1.4 \times 10^7 \text{ m}^3$) for the 1974-79 period. Total dissolved solids in Piceance Creek in the vicinity of Tract C-b generally range from 800-1,000 mg/L. The predominate ions are Na^+ , Mg^{++} , HCO_3^- , and SO_4^- . Fluoride in Piceance Creek in this area averaged about 0.7 mg/L during baseline.

A generalized water budget at Tracts C-a and C-b is shown in Table 6. At Tract C-a, dewatering is by wells and from the mine workings. At Tract C-b, all dewatering is from the shafts and workings. The "used" column in Table 6 includes dust control and processing at Tract C-a. At Tract C-b the water used includes dust control, sprinkler disposal, and leakage from three ponds. At Tract C-a, almost all excess mine water was reinjected during 1981, and at C-b almost all excess mine water was reinjected during the last few months of 1981.

Table 6. 1980-81 Water Budget
Tracts C-a and C-b
(all numbers in acre-feet, rounded)

	Dewatering	Reinjected	Discharged	Used
1980				
C-a	2860	2200	140	520
C-b	1460	0	910	550
1981				
C-a	2620	2150	4	470
C-b	1950	300	1010	640

At Tract C-a, the water discharged under NPDES permit flowed directly into Corral Gulch, thence to Yellow Creek. Most of the water discharged to date appears to have seeped into the normally dry stream channel and thus recharged the ground water in a reach several miles long downstream from the tract. Some water was evapotranspired along the channel.

At Tract C-b, the fate of the mine water is somewhat more varied. During 1980, about 690 acre-feet of the 910 acre-feet discharged under NPDES reached the gage near Piceance Creek, presumably most of the 210 acre-feet remaining seeped into the normally dry stream channel of Little Gardenhire Gulch and recharged the ground water in the Uinta Formation. During 1981, about 300 acre-feet were reinjected into the same aquifer zone from whence it was pumped, about 120 acre-feet were disposed of by sprinkling, about 170 acre-feet seeped into the channel of Little Gardenhire Gulch, a few hundred acre-feet were used for dust control and plant operations, and probably several hundred acre-feet seeped into the Uinta Formation from leaky ponds.

The discharge of mine water at C-b resulted in several measurable effects. The channel of Little Gardenhire Gulch (formerly known as No Name Gulch) has been scoured locally to depths of a few feet with an accompanying increase in sediment input to Piceance Creek. (Similar scouring and sediment transport occurred in Corral Gulch as a result of previous mine water discharge at Tract C-a.) The water of Piceance Creek normally contains about 0.7 mg/L of fluoride, 150 mg/L sodium, and 0.02 mg/L of total ammonia. In contrast, the mine water discharge, which during a few short periods was equal to or greater than the flow in Piceance Creek, contained about 18 mg/L fluoride, 550 mg/L sodium, and from about 0.2 to 2 mg/L of total ammonia. The resulting mix in a short reach of Piceance Creek below the discharge point, for short periods of time, contained more than 5 mg/L fluoride, 350 mg/L sodium, and from .1-1 mg/L total ammonia.

Flow in the White River at the Utah tracts averages about half a million acre-feet ($6.2 \times 10^8 \text{ m}^3$) per year. Water in the White River near U-a and U-b generally contains about 500-600 mg/L dissolved solids during most of the year.

2. Ground Water

At both Colorado tracts, ground water occurs in the Green River Formation, in the Uinta Formation, and in alluvial material along streams. Ground water occurs in joints, fractures, and intergranular spaces in the upper aquifer above the Mahogany Zone and in fractures and vuggy zones in the lower aquifer below the Mahogany Zone. Figures 6 through 9 show a general geologic section and the relationship of the aquifers at Tracts C-a, C-b, U-a, and U-b.

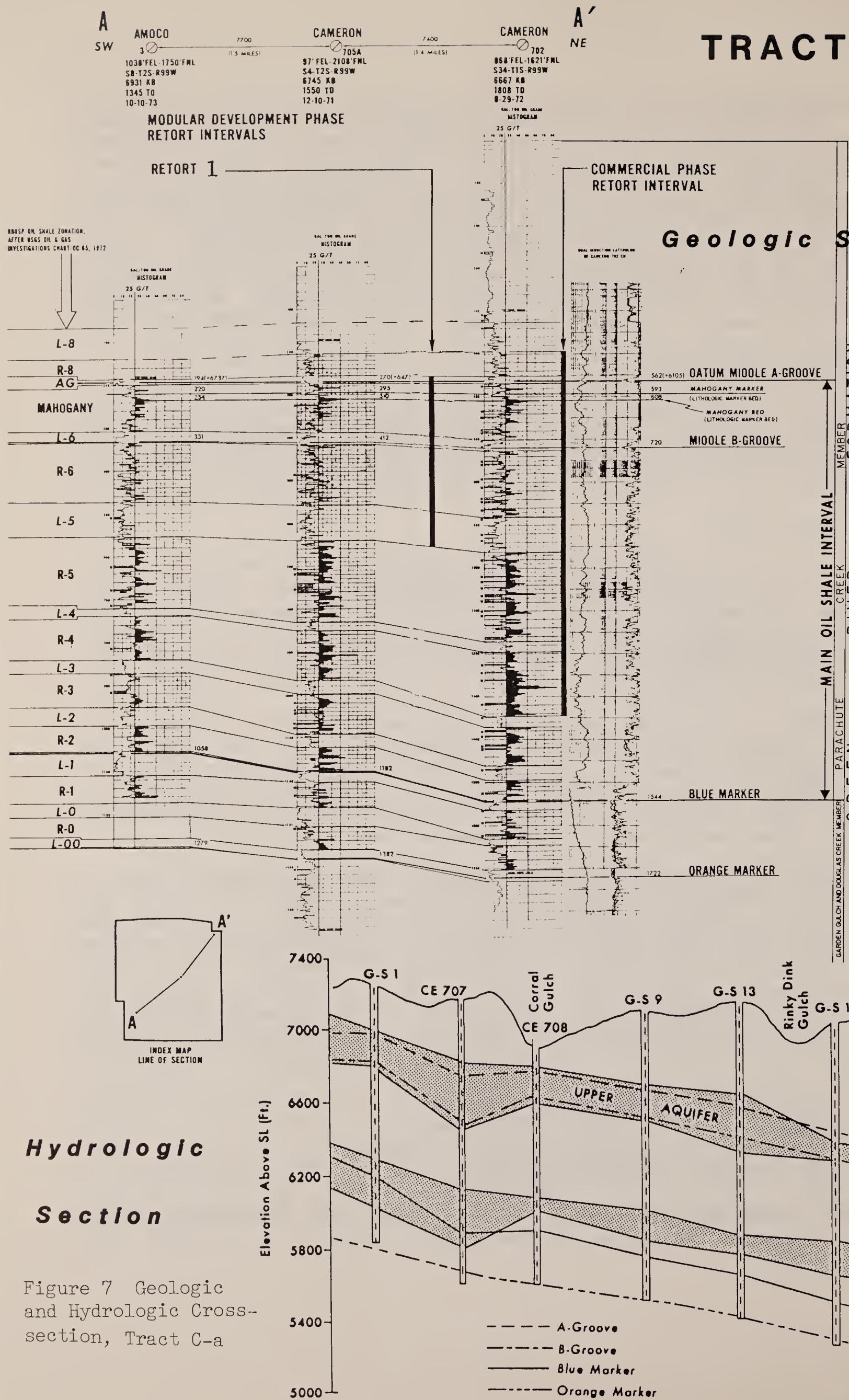
Dewatering of the upper aquifer at the Tract C-a mine has lowered the ground water surface approximately 700 hundred feet at the mine site. The cone of depression (Fig. 10) extends northwesterly, generally along the fracture system, and is restricted to the north, south, and east by reinjection wells. The reinjection of excess mine water has locally raised ground water levels from several ten's to a few hundred feet.

At Tract C-b, dewatering has lowered water levels approximately 1500' at the mine site. Although the amount of dewatering at Tract C-b is less than that at C-a, the cone of depression (Fig. 11) for the upper aquifer is much more extensive. The upper aquifer at C-b is more confined; therefore, a given amount of dewatering will produce a greater area of drawdown. As the three shafts were deepened, the cone of depression (Fig. 11) expanded quickly from December 1979 to September 1980. Four events since September 1980 should cause the eventual stabilization and perhaps local contraction of the cone of depression:

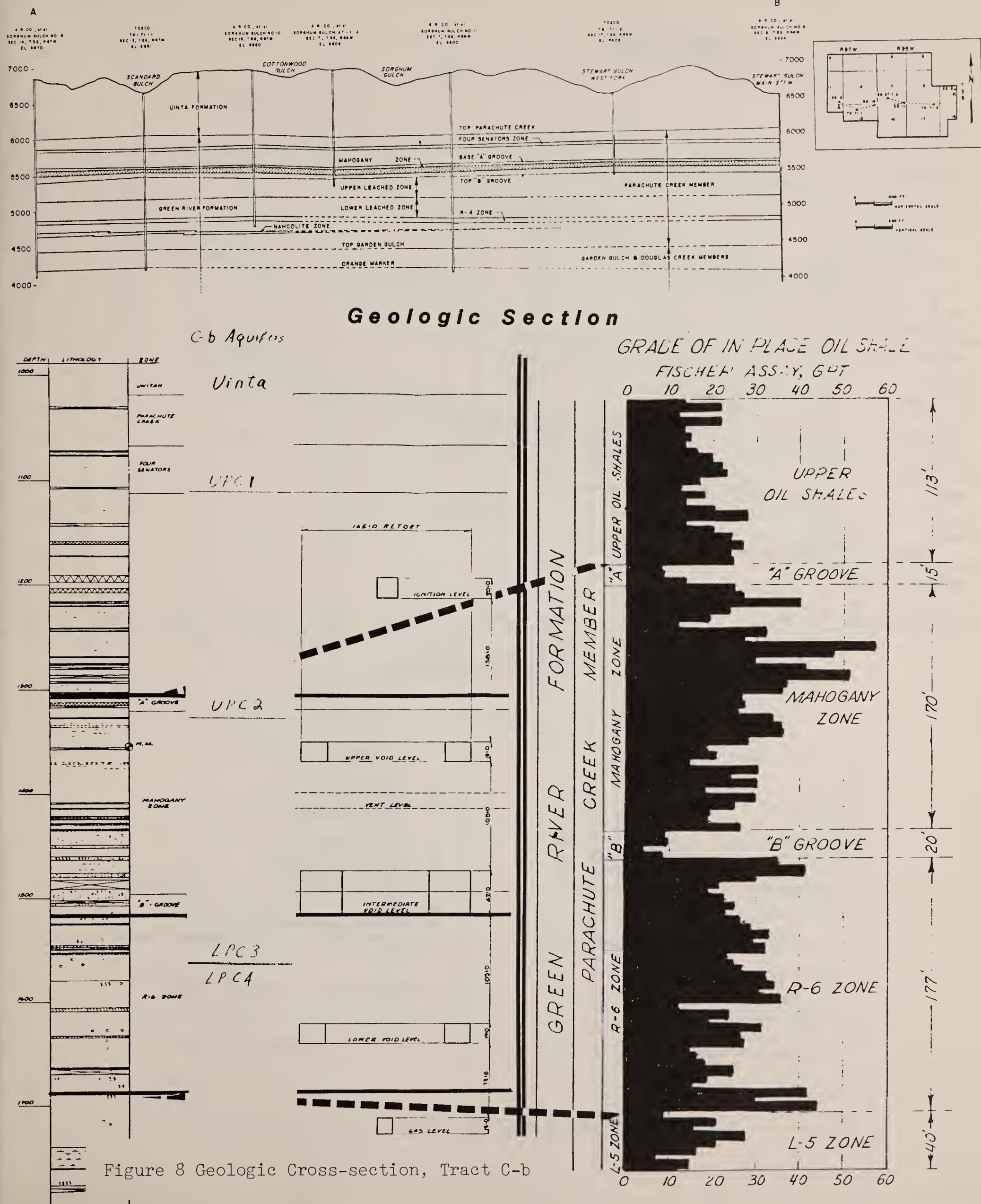
- a) completion of shaft sinking operation,
- b) installation of a reinjection system,
- c) curtailment of V/E shaft dewatering, and
- d) postponement of mine development.

During 1980, most deep monitoring wells on Tract C-b were recompleted to provide more precise monitoring of five separate zones of the ground water

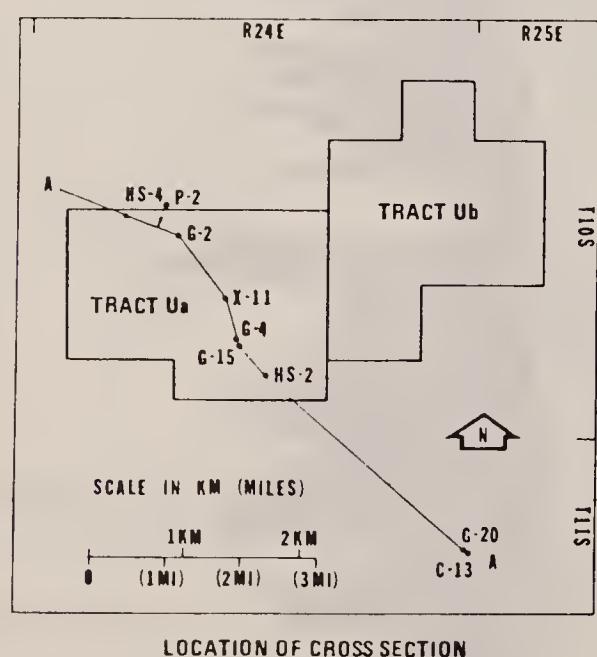
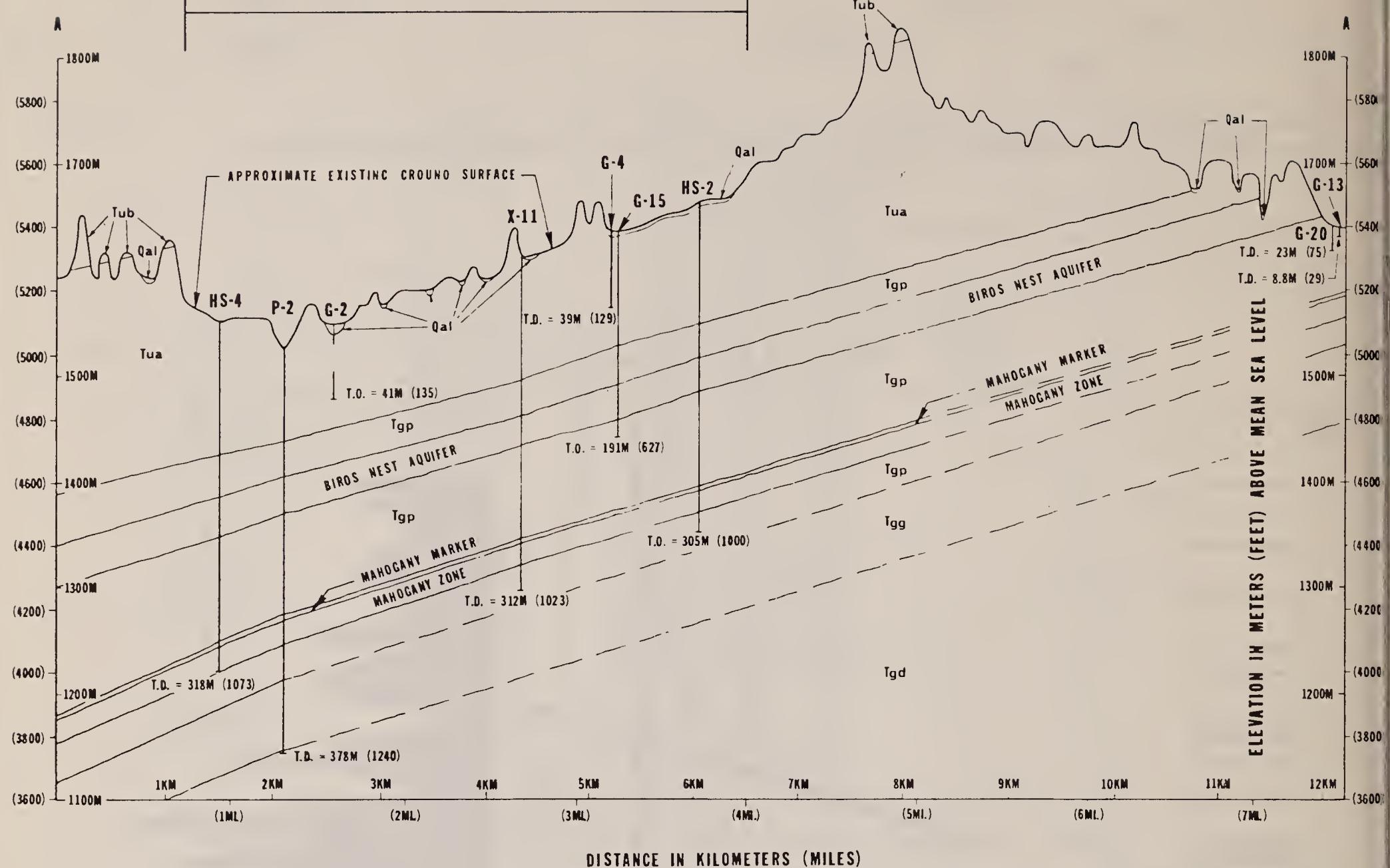
TRACT C-a



TRACT C-b



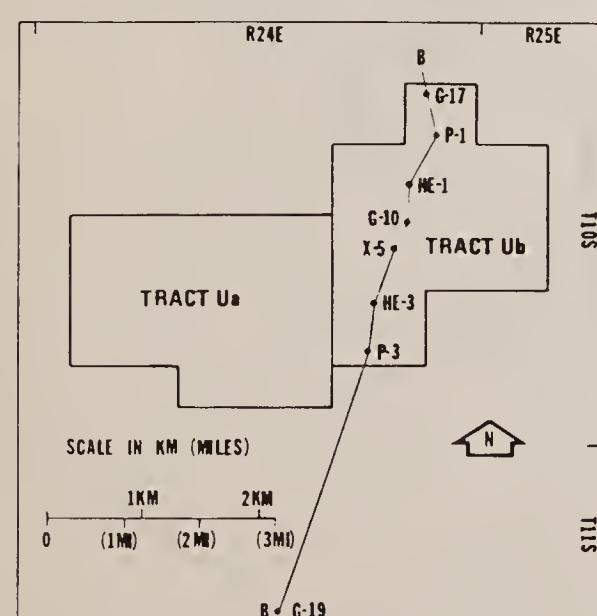
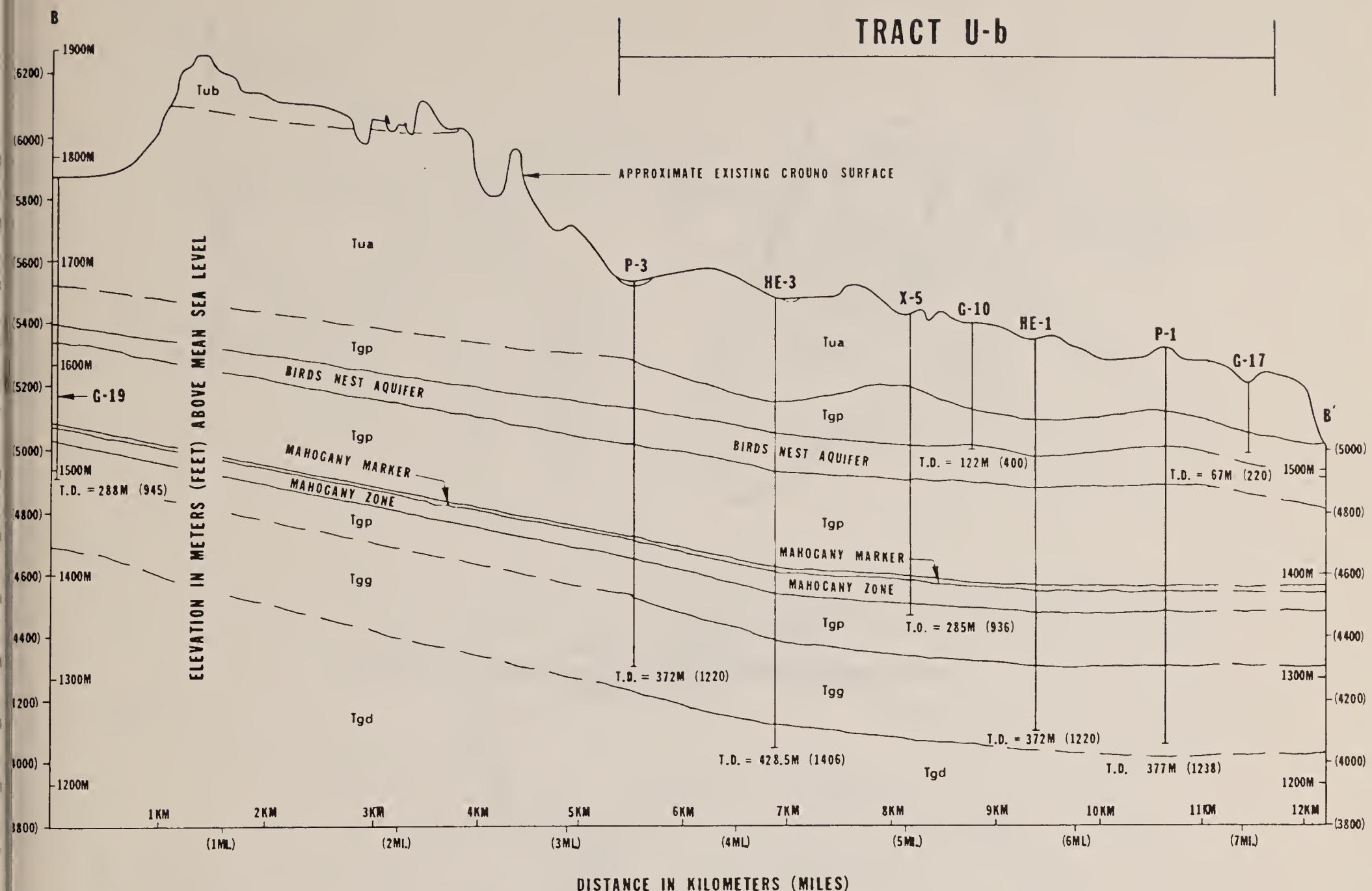
TRACT U-a



LEGEND	
Qal	QUATERNARY
~~	ALLUVIUM
—	EROSIONAL UNCONFORMITY
TERTIARY	
Tub	UNIT b
Tua	UNIT a
Tgp	PARACHUTE CREEK MEMBER
Tgg	GARDEN GULCH MEMBER
Tgd	DOUGLAS CREEK MEMBER
T.O.	TOTAL DEPTH OF BOREHOLE IN METERS (FEET)
X-5	BOREHOLES WITH PROJECT NO. DESIGNATION

NOTE: FORMATION CONTACTS DASHED WHERE INFERRED

Figure 9 Geologic Cross-section, Tract U-a



LOCATION OF CROSS SECTION

NOTE: FORMATION CONTACTS DASHED WHERE INFERRED.

Figure 10 Geologic Cross-section, Tract U-b

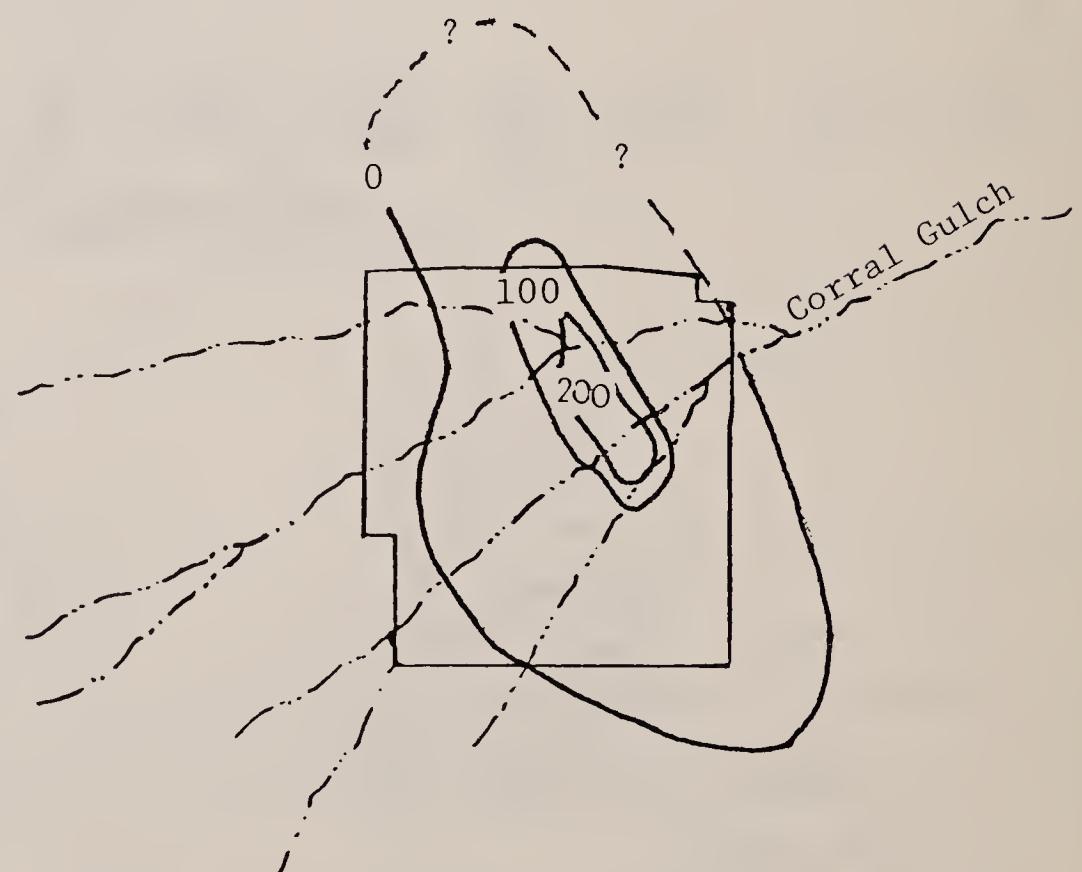
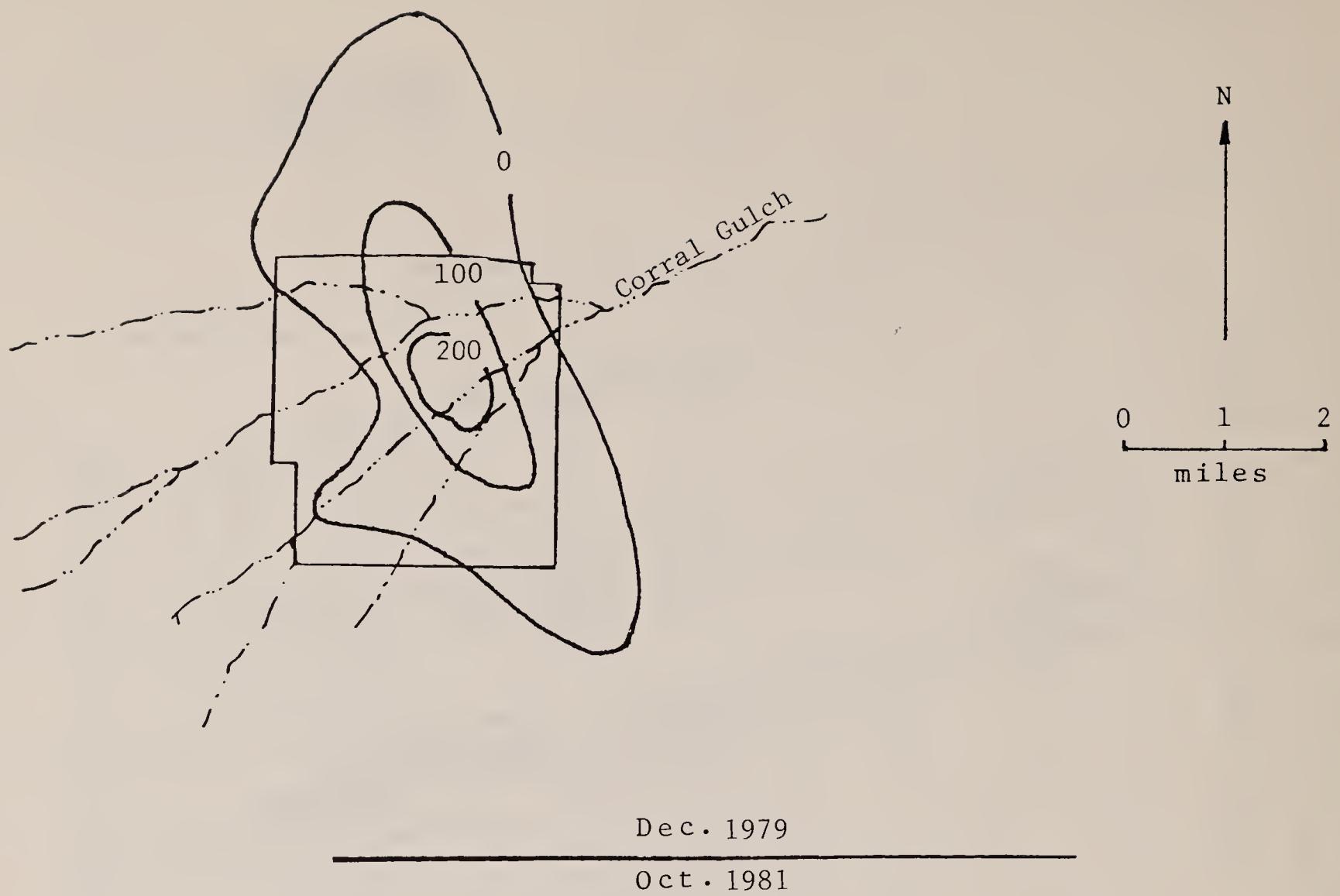
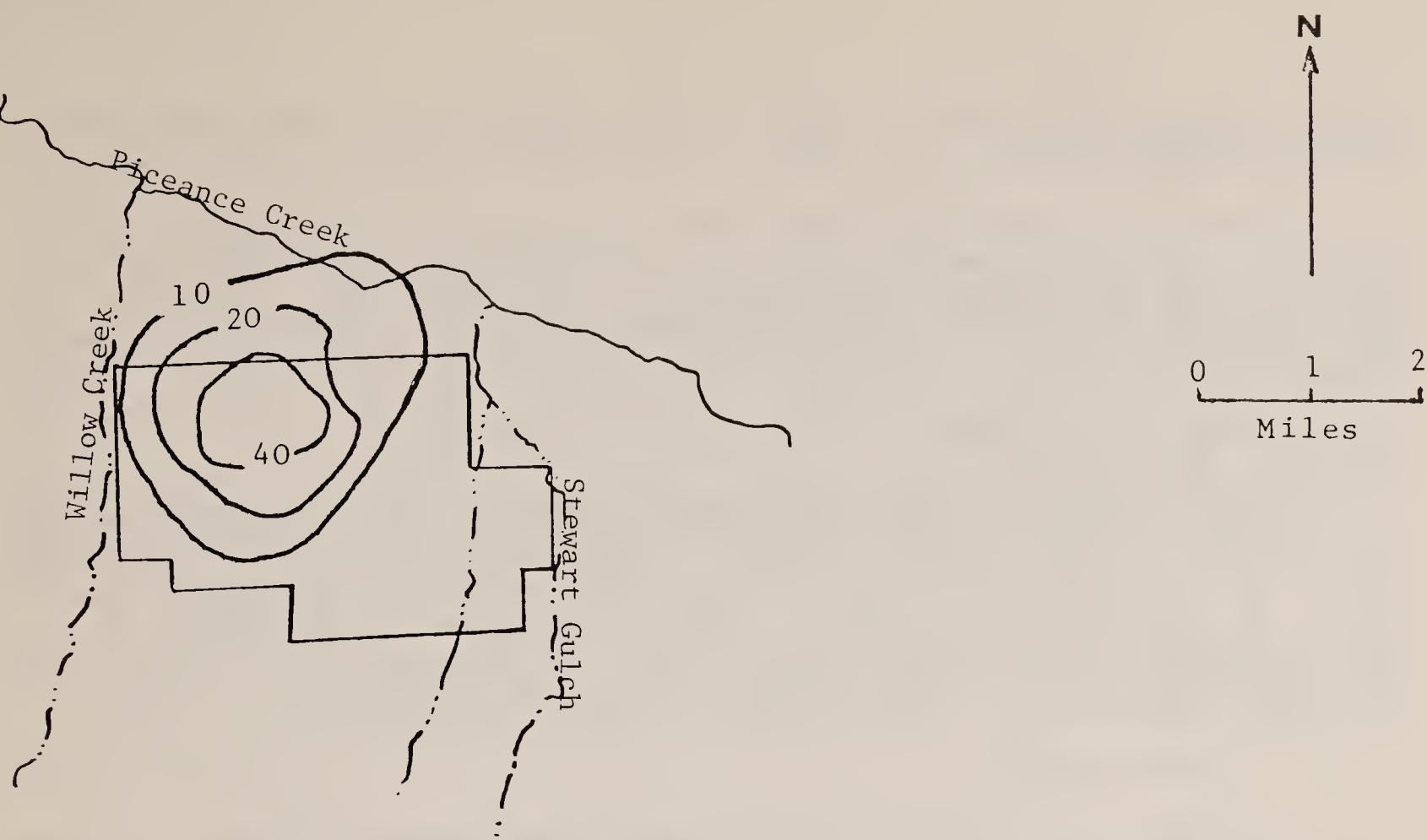


Figure 11 Generalized drawdown contours of upper Aquifer due to mine dewatering at Tract C-a.



Dec. 1979

Sept. 1980

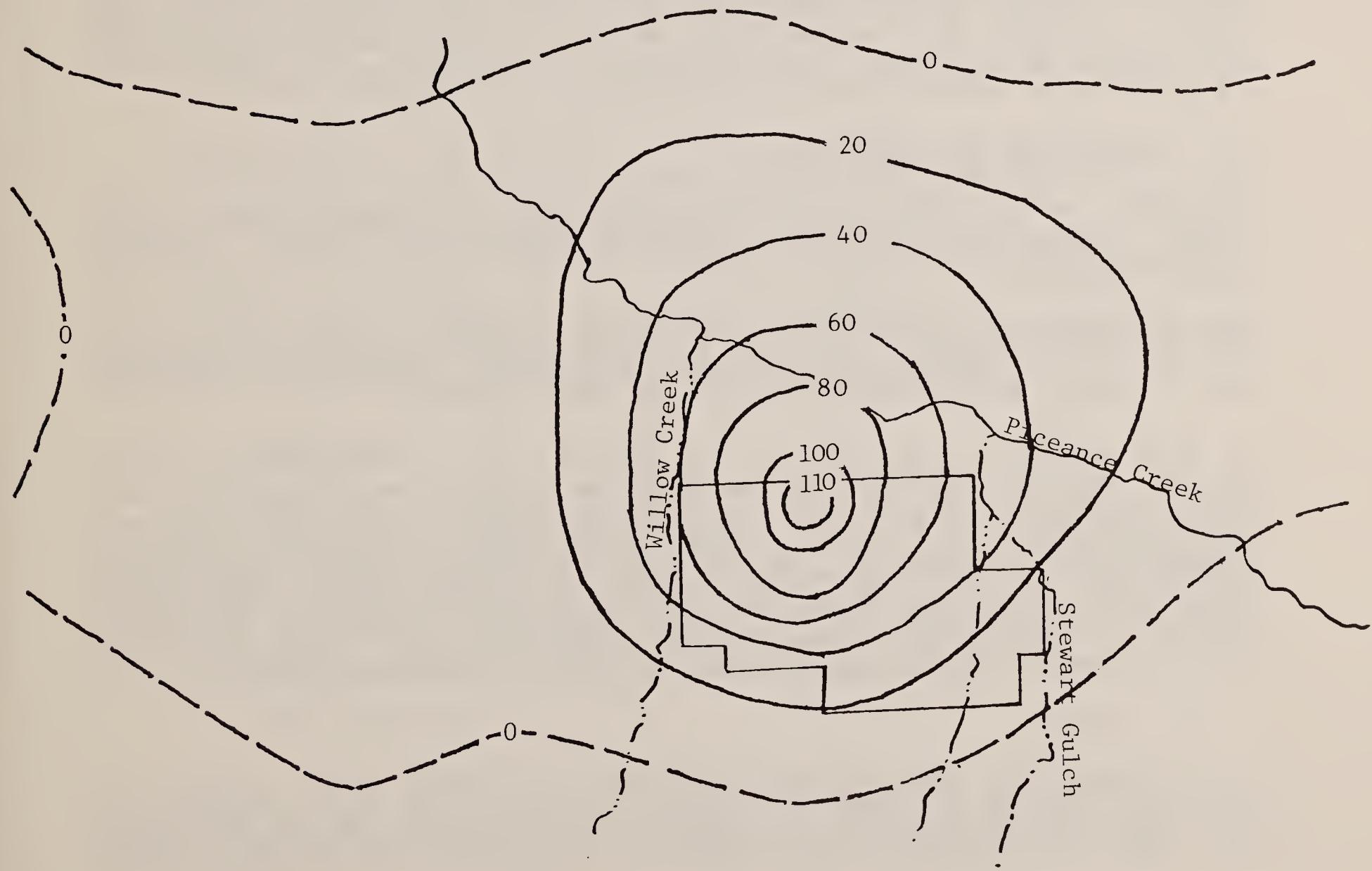


Figure 12 Generalized drawdown contours of upper Aquifer due to mine dewatering at Tract C-b.

system. These zones, shown on Figure 7, are important for mine dewatering and water management plans.

Ground water beneath the Utah tracts occurs in alluvial sand and gravel, fractures and intergranular spaces in the sandstones of both the Uinta Formation and the Douglas Creek Member of the Green River Formation, and fractures and vugs in the "Birds-Nest" Zone in the Green River Formation (Figs. 8-9).

3. Springs and Seeps

In the vicinity of Tracts C-a and C-b, about 40 springs and seeps have been studied, six of these in detail. These springs are closely monitored because of the potential effects of mine dewatering and other water uses on them. No clearly-defined effects related to dewatering have been noted to date, although local spring flows at Tract C-a have been affected by mine water discharge.

4. Shale Leaching

A Condition of Approval for the monitoring programs at both Colorado tracts requires study of the leachability of raw shale stored on the surface. Leachates from raw shale were found to contain as much as 20,000 mg/L dissolved solids. EPA is cooperating in the analytical phase of the study through a contract with Colorado State University. The USGS and DOE are also participating in the study. The potential for degradation of surface water and ground water supplies will be evaluated by this study.

B. Meteorology and Climatology

The climate of the Piceance Creek and Uinta Basins is classified as semiarid steppe. Intense solar radiation combines with dry air to create a generally pleasant climate.

Regional terrain strongly influences daytime temperatures and air drainage which results in complex surface winds. In general, the days are characterized by upslope air flow and the nights by downslope flow.

The meteorological monitoring not only provides data on the general climate but also provides information to estimate the impact of emissions that might result from oil shale development. Meteorological monitoring has been continuous since late 1974. Data are collected through a system of minicomputers and stored on magnetic tapes. The meteorological measurements include wind speed and direction, air temperatures, humidity, barometric pressure, precipitation, evaporation, turbulence, and solar radiation. Results of meteorological data analysis to date are summarized below:

1. Winds

The prevailing wind direction is from the WSW to SSW on the Colorado oil shale tracts and from the SE to SSE on the Utah tracts. Spring and summer have higher recorded wind speeds than fall and winter. The predominate wind

direction in the valleys is downslope at night and early morning and upslope during the daytime.

2. Temperature

The mean annual temperatures range between 43 and 48°F (6 and 9°C). The coldest temperatures were measured in the valleys because cold, dense air drains to lower elevations. During 1980, a maximum temperature of 91°F (33°C) and minimum of -15°F (-26°C) were recorded by the lessees. The 1980 growing season (frost-free period) of 151 days from May 12 to October 15 was the maximum recorded since 1975. Low-level temperature inversions occur on the tracts at night and they usually dissipate by early-to-mid-morning.

3. Humidity

During 1980, relative humidity on the oil shale tracts ranged from 99 to 7 percent. The annual mean relative humidity over the last five years has been 55 percent.

4. Pressure

Barometric pressure on the oil shale tracts ranged from 795 millibars (mb) to 759 mb during 1980. The 1980 annual mean (785 mb) compares well with the five-year mean of 787 mb.

5. Precipitation

Precipitation is measured at 32 sites on or near the oil shale tracts with weighing bucket gages, tipping bucket gages, and wedge gages. As in past years, large variations in precipitation occur from site to site. Variations of over 4 inches (10 cm) among gages at the same site were measured on one of the Colorado tracts during 1980. On the Colorado tracts, approximately 12 inches (30 cm) of precipitation were measured, compared with 10 inches (25 cm) on the Utah tracts. Because of the large variation in precipitation from location to location and the variation in gage efficiency, caution should be exercised in the interpretation and use of precipitation data.

6. Evaporation

Evaporation measurements are normally made during the growing season (between the months of April and October). Data were not collected for the entire season on the Colorado tracts. However, the data collected suggested that 1980 evaporation rates were lower than previous years'. On the Utah tracts, monthly evaporation ranged from 3.4 to 10.4 inches (8.6 to 26.5 cm). The average annual evaporation rate is 33.5 inches (85.2 cm).

7. Solar Radiation

Direct solar radiation is measured on the oil shale tracts with pyranometers. The 1980 data were similar to those of previous years and ranged from 658 langley per day in June to 117 langley in December. The daily range was 23 to 725 langley.

8. Upper Air Studies

Upper air studies were conducted during the first year of environmental baseline data collection. Special tracer studies have been made on both the Colorado and Utah tracts. All of these studies were discussed in the 1979 Oil Shale Office Management Report.

Since late 1977, acoustic radar has been in operation in the Piceance Creek Valley below Tract C-b. The thermal signature output on a continuous strip chart provides information (Table 7) on the average height, beginning, and end of temperature inversions. Temperature inversions occur when cooler air is trapped beneath warmer air in either valleys or basins. During the inversion, pollutants are trapped and concentrated rather than dispersed by normal air movement. Atmospheric stability classes are based on data temperature measurements from the 60-meter to the 10-meter levels on the meteorological tower. Based on the data collected, the nights and early mornings are typically stable while the hours between 0900 and 1900 are unstable.

In August 1980, a special meteorological program was conducted in Corral Gulch near Tract C-a. The study monitored and documented the characteristics of the nocturnal drainage and upper level winds. Detailed measurements were made on four nights using surface stations, balloon vertical profiles, an acoustic sounder, and the release and sampling of sulfur hexafluoride (SF_6) tracer. The SF_6 tracer was released up valley close to the in situ plant site. The results were published in Los Alamos Scientific Laboratory Report LA-8895-MS issued July 1981.

Table 7. Quarterly Average Inversion Heights and Durations
Over the Colorado Tracts

Month/Year	Average Height (M)	Onset Time	Breakup Time	Duration (Hours)
Sep 78 - Nov 78	303	1720	0820	15.7
Dec 78 - Feb 79	310	1700	0940	16.7
Mar 79 - May 79	323	1800	0740	13.7
Jun 79 - Aug 79	272	1900	0720	12.3
Sep 79 - Nov 79	266	1730	0840	15.2
Dec 79 - Feb 80	273	1600	1220	20.3
Mar 80 - May 80	283	1800	0740	13.7
Jun 80 - Aug 80	314	1820	0720	13.0
Sep 80 - Nov 80	355	1700	0920	16.3

From: 1980 C.B. Annual Report

C. Air Quality

There are three major characteristics of air movement that affect the transport of air pollutants. First, on a local scale, there is upslope movement in the daytime and downslope at night. Second, on a regional scale, the major movement of air, persistently from the WSW toward the ENE, tends to move regional pollutants NE along the valleys of the White and Colorado Rivers. Third, the region has a large number of temperature inversions. These may lead to high concentrations of ambient pollutants are trapped in the stabilized air.

Although there is little industrial or urban development in the region, high ambient concentrations of particulates, ozone, and non-methane hydrocarbons are occasionally measured. These high concentrations have also been measured in other rural, normally pristine areas. The particulate concentrations can be related to windborne dust in the arid, unvegetated regions. The high ozone and hydrocarbon concentrations have not been completely explained. They may be transported from more industrial and urbanized regions or the ozone may be transported downward from the troposphere.

Tract C-a

During 1979, 1980 and 1981, the following activities might have affected air quality:

- Outfitting and excavation of the Service/Production Shaft.
- Drilling blastholes for Retorts 0 and 1.
- Sinking of the Service/Escape Shaft, Off-gas Shaft, and Instrumentation Shaft.
- Rubblization of Retort 0 and 1.
- Ignition and burn of Retort 0 and 1. This was the only activity with directly attributable impact on air quality, as discussed later.

Pollution control systems in operation during 1980 consisted of:

- The incinerator-scrubber for off-gas from the Retort 0 burn.
- Application of water and dust palliatives on unpaved roads and work areas.

Tract C-b

Activities at Cathedral Bluffs which could affect air quality were:

- The sinking of the Production, Service, and V/E Shafts.
- Truck movement on haul roads.
- Operation of a concrete batch plant
- Construction of ponds.

There were two air pollution control systems in operation:

- Baghouse on the concrete batch plant.
- Application of water and dust palliatives on unpaved roads and work areas.

Tracts Ua/Ub

There have been no development activities on these tracts. The monitoring program is basically a small extension of the baseline program. It validates data trends measured during the Baseline Program and notes significant deviations from those trends. The prime objective was to determine if the high levels of ozone and non-methane hydrocarbons occasionally measured during the baseline period recurred during the lease suspension period.

1. Air Quality Monitoring Activities

Monitoring activities for 1980 at tracts C-a and C-b were designed to detect changes in air quality related to tract development. Monitoring at Tracts U-a and U-b continued data collection that commenced during the baseline monitoring period.

2. Discussion of Results of Monitoring and Data Analysis

C-a and C-b: Analysis of air quality data from both Colorado tracts suggest these similar conclusions:

- There is no significant, long-term effect on air quality by tract development.
- Air quality is characteristic of a clean air region with no major, stationary pollution sources nearby and no urbanization.
- The concentrations of all pollutants, except ozone, are at or below the threshold of instrument detection.
- The measured concentration of ozone occasionally approaches the maximum permitted by the National Ambient Air Quality Standard. Regression analysis suggest that these high concentrations correlate with season and meteorological conditions. Possible explanations for these ozone concentrations are long-range transport of ozone from urbanized, industrialized areas or downward entrainment of ozone from the troposphere.
- Data summaries for all tracts are available in each lessee's annual and quarterly reports.
- In summary, most variations in ambient concentrations of pollutants are related to short term or seasonal variations in meteorological parameters.

U-a/U-b: Air quality at the tract continued to be consistently good.

The only gaseous pollutants present in measurable quantities were non-methane hydrocarbons and ozone. Most measurements were near or below the threshold of detection for the instruments. The pattern of occasionally high concentrations of ozone and nonmethane hydrocarbons continues from the Baseline Period. It is best explained by seasonal weather variations and downward mixing from the tropospheric ozone reservoir. Total

suspended particulate concentrations have decreased continuously since the Baseline Period. This corresponds to a decrease in average annual wind speeds at the tract.

3. Permitting Status for Air Quality

C-a: Rio Blanco Oil Shale Company holds valid permits from the State of Colorado and the U.S. Environmental Protection Agency (EPA) for the Modular Development Phase of their activities. They recently received preliminary approval of their application for a Prevention of Significant Deterioration (PSD) for the Lurgi demonstration project.

C-b: Cathedral Bluffs Shale Oil Company holds a permit from the U.S. EPA for PSD for their development phase up to 5000 BBL/day of production and has submitted a PSD permit application for a full-scale commercial operation. This has been judged a complete application by EPA Region VIII and is presently under review by them.

U-a/U-b: The White River Shale Project currently holds no air quality permits for development.

4. Joint Visibility Monitoring Project, C-a and C-b

The visibility monitoring program is a shared project of Tracts C-a and C-b. During 1980, measurements were taken every sixth day for a total of ten observation days in the spring quarter and ten days in the fall. The project was undertaken as a requirement of the Federal Prototype Oil Shale Lease Environmental Stipulations.

The purposes of the measurements are to establish baseline visibility for the Piceance Basin, to identify any long-term deviation from the baseline, and to establish correlations between visibility and meteorological or air quality parameters.

During the observation periods, photographs are taken at hourly intervals from an observation site on a ridge between Hunter Creek and Dry Gulch eight miles SW of Piceance Creek. The photographs are taken of each of the four view targets shown in Figure G.2.3-1.

The results from 1980 measurements indicate a slight increase in visual ranges in the Piceance Basin. The mean annual visual range for 1980 was 85 miles, as compared to 79 or 80 miles for earlier years. There is a large day-to-day variation in visual range which is primarily dependent on meteorological conditions. The maximum range measured in 1980 was 176 miles, compared to about 150 miles during each of the three previous years. These ranges approach the theoretical limit of visibility.

5. Noise Monitoring at C-a and C-b

C-a: Two noise surveys were taken during the reporting period. The sound levels generally ranged from less than 30 dBA (the threshold of the instrument) to 50 dBA, except near the main construction area (adjacent to the

headframe) where it averaged 71 dBA. If the measurements taken near the main construction area are excluded, these sound levels are comparable to data taken during the baseline period.

C-b: Environmental noise monitoring continues to focus on traffic and construction noise. The average noise level was less than 44 dBA. Compliance with State of Colorado noise standards for an industrial zone was achieved, although the tract is not classified as industrial at this time.

Monthly peak noise levels and background levels during the development period exceed those of the baseline period by an average of 9 dBA. This increase is most likely due to construction activity.

6. Quality Assurance Audit Program

In 1980, all tracts participated in an external audit of their air quality monitoring programs for quality assurance. Quarterly, C-a tract monitoring apparatus is exposed to a known concentration of a particular pollutant. A portable monitor (the "audit" device) is then exposed to the same concentration of the pollutant. The response of the monitor is then compared to the audit device.

For all four tracts, the audit program confirmed that reliable data is being collected. Most on-site monitors agreed with the audit device to within $\pm 10\%$. This accuracy is acceptable to the audit program. The monitoring audits detected several minor problems, including minimizing instrument down time, maintaining quality of calibration gases, and standardizing calibration methods.

D. Reclamation

1. General Philosophy of Reclamation

Federal, state, university, and private energy groups have conducted field and greenhouse experiments to determine suitable reclamation and revegetation practices on mined lands in the oil shale region. Objectives have been to study and compare the effects of various reclamation practices on disturbed ecosystems and to develop management practices for establishment of self-sustaining ecosystems.

Experiments are being conducted with different plant growth mediums and mixtures including topsoil-like material, subsoil, overburden spoil, raw shale, and processed shale. Various seeding mixtures are being evaluated to determine the optimum planting materials to comply with existing regulations and meet the needs of the newly established ecosystems. Other research objectives are determining requirements for: irrigation and mulching; rates and direction of plant succession and optimum plant mixtures for topsoil, subsoil, overburden, and retorted shale.

Various seed mixtures are being studied for their suitability for stabilizing and revegetating stock piles and disposal piles for raw and processed shale. These studies are focusing upon growth and maintenance

requirements for native and introduced species and include specific studies upon time of seeding, type of mulching, fertilizer time and rate of application and the possible requirement for supplemental irrigation. These studies and demonstration sites are designed to meet the Prototype Lease requirements that adequate reclamation technology must be demonstrated within a ten-year period following approval of the Detailed Development Plan.

Although no conclusive studies have been completed to date, there is good evidence that both native and exotic plant species can be grown over processed shale material provided specific site requirements are met. Before processed shale can be revegetated, it must first be leached with massive amounts of water (the Colony operation tests took 39 inches of water to leach salts below plant root zones) and then heavily fertilized with a complete fertilizer. Although the Colony revegetated shale plots are still thriving ten years after initial establishment, the partially shaded canyon test site may not be representative of most planned spoil pile situations. A major problem in the arid West is the high demand for scarce water for leaching the shale and the dark surface which reaches high surface temperatures during the summer growth period. While warm soil temperatures are critical for seed germination, excessive heating burns young plants. The high salt content of unleached shale material restricts all but the most salt-tolerant species. Retorted shales also produce distorted root growth in surviving plants.

A reclamation/revegetation method has been developed that precludes the need of extensive leaching and fertilizing of surface heating of the planting medium. The method uses a rock rubble substrata about 100 cm (40 inches) thick to provide a capillary barrier to upward migrating salts and a topping of topsoil-like material about 30-45 cm (12-18 inches) thick.

Early indications are that the greater the site disturbance, the slower the invasion of native plants and faster invasion of annual and undesirable plants. Early application of fertilizer on disturbed sites were found to also encourage annual and undesirable plant invaders.

Soil depths needed to sustain shrub cover have not yet been established, although past experience indicates shrubs may require a greater soil depth than grasses. Some plants grown over processed shale may extract toxic elements (e.g., boron and molybdenum) from the spent shale. This could cause plant loss and/or toxic symptoms in grazing animals. These problems are either currently being studied or are planned for investigation by various researchers in the near future. Also under study are effects of slope, aspect, temperature, irrigation, season of planting, and toxic leachate effects upon revegetation success.

Based on the information developed in the POSLP, these are some recommendations for future research in reclamation:

- Identify and monitor succession of plants on reclaimed sites for ten or more years,
- Measure the effect of soil nutrients and microbial activities on reclamation success,

- Identify the optimum mixtures of plant species, fertilization times and rates, planting procedures, and depths of soil over processed shale, and
- Identify the effect of capillary barriers between shale and topsoil on plant growth success.

Also needed is a long-term evaluation of the role in revegetation of native and introduced legumes as well as the need for mycorrhizal inoculation of soils for reclamation success.

2. Reclamation of Disturbed Land

The POSLP requires the lessee to reclaim all disturbed areas to their original use and productivity. Reclamation of disturbed areas on Tracts C-a and C-b has been successful thus far. Plant succession has returned the areas to a near natural state, similar to the condition on undisturbed lands. Species density and composition are similar to those on undisturbed lands. Erosion has been controlled to acceptable limits.

There has been no surface retorting on any tract. Thus, no reclamation experiments with prototype lease processed shale have been conducted.

Topsoil, overburden, and raw shale have been produced by mine shaft and facilities development and are stockpiled separately. The soils are stockpiled for future reclamation use. Overburden is used for fill, road construction, and dikes. Raw shale is stored for future retorting.

Based on the experience gained in the POSLP, the OSO provides technical representation to the Advisory Board of the Upper Colorado Plant Materials Center in Meeker, Colorado. The Board determines "superior" plant species for reclamation. These superior plants are used to reclaim surface disturbances related to oil shale, coal, highway development, and other activities. Commercial growers are the sources for these plant materials.

E. Ecosystem Interrelationships

This term is applied to the integrated life support system, specifically on the lease tracts but also in the oil shale region in general. The Federal Prototype Lease Environmental Stipulations, CFR 38:230, Sec. 1B(2)(d), states: "The lessee shall also study and report to the Mining Supervisor on ecological interrelationships including migratory patterns of birds, mammals, fish, and plant-animal relationships."

This rather general requirement can be interpreted in various ways; however, for the purpose of conducting a uniform and effective monitoring program, the Oil Shale Office considers two principle types of ecosystem interrelationships - one general and one specific.

General Ecological Interrelationships are interpreted to be those major processes that govern the stability and resilience of the tract ecosystem. Thus broad scale intra- and interrelationships among important components and processes are considered. Judgments concerning impacts upon these integrated systems are based on knowledge of ecosystem theory and upon interdisciplinary

team discussion and agreement. The OSO and both C-a and C-b tract lessees have or are developing conceptual and qualitative ecosystem models to focus monitoring studies on the most important relationships that have the highest probability of being affected. Mitigation and control of impacts will focus on the key relationships being monitored.

A major and continuing problem has been to achieve a consensus among specialists and managers of industry and government on those key environmental components and processes that govern the oil shale tract ecosystems and that have a high probability of being significantly impacted. Several workshops to address this problem are planned for 1982. The Oil Shale Office Staff will participate in a workshop planned for this summer by the Battelle National Laboratory, Richland, Washington, designed to determine statistically valid monitoring approaches for the oil shale regional ecosystem. The Northwestern Colorado Wildlife Consortium also is proposing to conduct a workshop using the Adaptive Environmental Assessment methods developed by C. S. Hollings group at the University of British Columbia. This workshop will focus on methods to determine impacts on mule deer by ongoing and proposed energy development projects in NW Colorado.

Analysis and conclusions drawn from the lessees' environmental baseline program have indicated some important general ecological interrelationships that require more specific studies.

C-b lessee determined an important interrelationship between water quantity, quality, and temperature of mine discharge water and toxicity to biological organisms including man. Fluoride toxicity to biota is a function of temperature and concentration; thus, as receiving stream temperature rises, toxicity increases. However, as stream temperatures rise in spring and early summer, stream flows increase from runoff and the resultant dilution can result in a net decrease in toxic concentration of fluoride in downstream waters. Thus, regulatory requirements based on single parameter monitoring and analysis may be both erroneous and counterproductive.

Another example of how interrelationships play an important role in monitoring is the interaction of precipitation to plant toxicity to air pollutants in the desert environment. Desert plants protect themselves from desiccation by developing a tough, waxy surface covering and closing their stomatas to reduce moisture loss. During dry, hot weather, they are very resistant to damage from SO_2 and NO_x because of previously-described protective strategy. However, during periods of increased moisture, stomatal openings increase and result in increased damage to plant cells from these airborne pollutants. This knowledge can be used to design control technologies that maximize emission operations while minimizing vegetation damages.

The relation of deer mortality to increased vehicular traffic to and from the lease sites led to busing of employees and installation of reflective highway markers to decrease deer-car collisions. These are just a few of the interrelationships being studied on the POSLP.

Specific ecological interrelationship studies are designed to quantify those interactions indicated as important under the general interrelationships. Every testable hypothesis in the lessees' monitoring program involves

interrelationships. Comparing sampling plots over time and among years involves the interrelationship of several parameters and variables. There is the relationship of the item or parameter measured and locations (space variables). There is a relationship between the parameter measured (dependent variable) and time such as day, season, year, etc. (independent variable). These relationships are quantified by statistical procedures such as correlation, regression, co-variance, etc.

Specific ecological interrelationships are thus analyzed as mathematical relationships between and/or among dependent variables and/or independent variables and are designed to answer important and relevant questions concerning if and how items are interrelated. These determinations are then used to make management decisions regarding control and mitigation of environmental impacts.

- The relationship between climatic variations and annual herbaceous production, and
- The relationships between traffic volume, deer populations, and deer killed on the Piceance Creek road.

Other relationships being studied qualitatively are:

- The relationship between herbivore density and shrub utilization, and
- The relationships between shrub production, utilization, deer migration, age/sex ratios, pellet groups, and climate, with respect to deer mortality.

The most significant relationship determined to date on the C-b tract is the high correlation between deer killed on the Piceance Creek road and the volume of vehicular traffic. Another relationship (also determined elsewhere) is the positive correlation between herbaceous production and growing season precipitation.

RBOSC, rather than developing a conceptual model of C-a's ecosystem, has instead concentrated on identifying several specific ecological interactions. The two interactions under study are:

- Interactions of precipitation and range production and
- Interaction of the mule deer population and browse utilization.

Analyses to date suggest that summer precipitation largely governs grass productivity, especially those with rhizomatous root systems. Another interesting facet is the apparent bi-modal growth pattern exhibited by cool season plants. Growth occurs during spring and again in late summer, corresponding to the precipitation patterns in this semiarid region.

Decreases in mule deer populations from 1978 to 1980 were also reflected in the lighter browse utilization during the latter period.

The OSO plans to improve understanding of ecological interrelationships of the tract areas. Data from Tracts C-a and C-b will be combined. Various analytical methods and simulation models will be applied. As more tract and regional data is collected and as the impacts of large development are studied, interpretations of ecological interrelationships will become more reliable.

F. Biological Resources

1. Flora

The Prototype tracts are located in the pinyon-juniper ecosystem. Vegetation types include saltbush, sagebrush, grassland, and mountain shrub/grassland. Herbaceous forage productivity varies between 200-500 lbs/acre on the Colorado tracts and 0-2,000 lbs/acre on the Utah tracts.

With one exception, environmental monitoring of vegetation shows little change from previous years. The largest change was browse utilization; it declined on both Colorado tracts. This decline is consistent with a declining deer population in the Piceance Basin. Average browse utilization on Tract C-a varied by vegetation type from 1 to 10% in the 1979-80 winter. Average browse use of the same transects was 4-8% in the 1980-81 winter. Browse use was also 10-15% less on Tract C-b in 1980-81, compared to 1979-80.

Biomass production on the Utah tracts continues to vary widely in response to moisture during the six years of monitoring. Even though 1980 growing season precipitation was near average, biomass productivity ranged from 195 Lb/ac for the shadscale vegetation type to 5 Lb/ac for the juniper type, which is below normal.

2. Terrestrial Fauna

With regard to the Piceance Basin, there have been no significant changes in terrestrial fauna compared to data from previous years with the exception of mule deer. Their population continued to decline throughout the Piceance Basin. The 1979-80 winter deer population was only 15,428 (+3,458), which is approximately one-half of the 1978-79 population. The 1980-81 population is thought to have increased slightly because mortality was lower during the milder-than-normal winter. However, the mild winters did not concentrate the deer enough to permit aerial censusing.

On Tract C-a, the estimated average number of deer per square mile dropped from 43 in 1978-79 to 28 in 1979-80 to 24 in 1980-81. Continued decline in 1980-81 is partly due to the very mild winter which allowed the deer to winter on the Cathedral Bluffs. Interestingly, Tract C-a itself continues to have the highest deer densities in the 81 square-mile study area. Each year Tract C-a, block 5, supports more deer than the other eight blocks in the study area, despite development activities.

On Tract C-b, analysis of fecal pellets counted in 1979-80 suggest little change in deer density compared to data from the previous year. This would be expected as C-b lies within the main wintering area. Even though the overall

population is less, the heavy snowfall kept the remaining deer concentrated on their winter range which includes Tract C-b. The area near Sorghum Gulch continues to have very high deer densities compared to the other study areas, despite tract development. Pellet group data for 1980-81 showed a further decline in deer wintering on C-b, but this was due partly to the very mild winter which allowed the deer to winter at higher elevations than normal. The most striking effect of the mild winter in 1980-81 was in the deer mortality. A total of 16 carcasses were found for a carcass/hectare ratio of 0.227, the lowest recorded since 1974-75.

In the winter of 1979-80, a study of daily and seasonal deer movement patterns was started on Tract C-b. It is funded by DOE and jointly conducted by the Colorado Division of Wildlife and the Los Alamos National Laboratory. Twenty-seven fawns were trapped, and collars with radio transmitters were attached. With the collars, daily and seasonal movements of the fawns could be recorded. Within the first year, 20 of the fawns were killed, most of them by coyotes. The surviving fawns migrated to their summer range on the southern edge of the Roan Plateau. During December 1981, the original study was expanded. Radio collars were placed on 31 male and 35 female fawns and 24 does. Two types of collars were attached to the fawns to permit testing the hypothesis that the collars contribute to the predation rate. At the end of 1981, 117 animals were being tracked by radio collars. This intensive tracking will identify the deer's movement patterns and their preferred habitats.

The results of this study will be applied to reclamation of disturbed areas and to mitigation of development activities. This study will address several questions, e.g., what routes of travel are used between winter and summer range, how long does migration actually take, what part of a slope do deer use, and what part of a particular habitat do deer use? The answers to these questions will guide reclamation to ensure that the deer's preferred habitat is always present on or near the tracts.

Every other year, a golden eagle has used a nest immediately adjacent to the entrance road to Tract C-a. This road has been upgraded and resurfaced increasing vehicular traffic, but there has been no increase in pedestrian traffic around the nest site.

Wildlife has a remarkable ability to adjust to the pressure of people in their home range as long as they are not harrassed. Vehicular traffic is restricted to roads. Employees are not allowed to chase wildlife or to indiscriminately wander around outside of the actual development site.

3. Aquatic Flora and Fauna

Only aquatic monitoring stations 13 and 14 on Corral Gulch below Tract C-a produced data different from previous measurements on the lease tracts. Station 13 was affected by increased mine water discharge. Species diversity decreased during the spring, but increased during the summer and fall. Station 14, above the confluence with Yellow Creek, is a small manmade pond. It washed out in late winter of 1980. Increased flow scoured the bottom of sediment. The dam was rebuilt and flow was reduced; however, the aquatic flora and fauna have not yet returned to their normal levels.

4. Habitat Management

North of Tract C-b, a brush beating project was initiated in Oldland and Gardenhire Gulches. The sagebrush was killed with a roller chopper during the winter of 1979-80. The chopper blades break and cut the sagebrush stems. This kills the plant since sagebrush will not sprout from roots. Some sagebrush was left standing along the stream channels and sideslopes above the flood plain to provide travel lanes for the deer. After chopping, the areas were reseeded with cool season grasses, as well as four species of palatable shrubs. The early growing grasses will provide green feed shortly after snowmelt. Hopefully, this will hold deer there and keep them from going down to the meadows on Piceance Creek. If so, it will help reduce the deer road kill. Deer use on these areas was virtually none in the 1980-81 winter due to the almost total lack of snow which caused the deer to winter at higher elevations than they normally do.

On Tract C-a, the sagebrush chopper chopped strips in the tall sagebrush in Stake Springs Draw. Four strips were chopped parallel to the prevailing wind and four at right angles and seeded. The orientation of the strips will have a major effect on snow accumulation and thus vegetative response. Different fertilizer and seed mixtures were applied to test deer response. Again, the lack of snow in the winter of 1980-81 essentially negated this test.

A cooperative study was initiated in December 1981 to test the effectiveness of a new reflector to reduce deer road kills. Rio Blanco Oil Shale Company, Cathedral Bluffs Oil Shale Company, Multi Mineral Company, Colorado Division of Wildlife, and the Oil Shale Office are all funding the project. The reflectors will be installed on four, one-mile stretches of the Piceance Creek Road which have recorded the highest deer road kills. Personnel from C-b tract will alternately cover and uncover the reflectors every week and record the number of deer killed. By alternately covering and uncovering them, each section becomes its own treatment and control section. This eliminates weather and topography as variables and allows statistical testing of the data.

The reflectors operate by reflecting car headlights off the road as a red color. The red glow from these reflectors is supposed to momentarily freeze the deer in place. This allows the car to pass the deer before it can dart in front of the car. The reflectors have been used extensively in Europe where they are claimed to be extremely effective. They have not, however, been subjected to a good controlled test to statistically prove or disprove their effectiveness.

In 1980, the difference in browse utilization between fertilized, irrigated, and naturally-occurring sagebrush was measured. Based on visual observation of browse utilization, the following conclusions can be drawn:

- (a) Fertilized and irrigated sagebrush was the most preferred browse.
- (b) Irrigated, but unfertilized, sagebrush was preferred over naturally-occurring sagebrush.

In an effort to determine what chemical changes occurred in the sagebrush, the OSO designed a test. Tract C-b again fertilized the plot in 1981. In the fall, ten sagebrush plants were caged in each of two treatments areas and a control area. The cages will prevent deer from browsing those plants. All sagebrush plants caged were of the same subspecies, Artemesia tridenta vaseyana to reduce plant variation.

In the fall before deer migrated down, productivity measurements were taken by OSO personnel on a similar sagebrush of the same subspecies near each cage. They will be remeasured in the spring to determine utilization by deer.

At the peak of deer use, plant samples of the caged plants will be taken and subjected to chemical analysis. In this way, it is hoped the reason for the increased palatability of sagebrush can be determined. This could have tremendous potential for increasing deer carrying capacity of sagebrush ranges. Irrigation and fertilizing are too expensive a method; however, once it is identified why palatability increased, then more economical methods for achieving this can be tried.

5. Endangered Species

The U. S. Fish & Wildlife Service (USF&WS) captured several fingerling Colorado River squawfish near Ignacio in the White River during the fall of 1980. In addition, an adult squawfish was radio-tagged at Split Mountain near Vernal, Utah, and followed down the Green River and then up the White River to Rangely, Colorado. It finally returned to the mouth of the White River. This trip covered over 200 miles in a two week period.

An intensive survey of the White River was completed in 1981 by the USF&WS. The study will delineate the habitat of Colorado River squawfish, humpback chub, and bonytailed chub. Very little is presently known about the requirements of these endangered fish.

Bald eagles again were seen occasionally on all tracts during the winter months as they foraged away from the White River. No nests were found as the bald eagle migrates north to its breeding grounds each year.

No other threatened or endangered species were found on or near the tracts.

Several plants, which have been proposed as threatened or endangered, were found in the vicinity of the tracts, but not on them. The Milkvetch Astragalus lutosus was located at several places near the C-a tract, including one site along the main access road. OSO staff found one plant growing on the shoulder of the road to C-a within a foot of the blacktop. Barneby's Columbine, Aquilegia barnegyi, and the fescue, Festuca dasyclada, have also been located at several points in the Piceance Basin. All three of these species are endemic to outcrops of the white clays of the Green River Formation. Barneby's Columbine prefers a more mesic habitat, usually a site where seeps occur in this formation. Considerable numbers of the other two species grow on SW exposures of this barren clay. They might be excellent plants for revegetation of this exceptionally harsh habitat.

A new species of Penstemon, called the White River Penstemon, Penstemon alba-fluvis, was found on a north slope, directly north of the White River. The species has not yet been given a species name. The only two other known occurrences of this plant were on barren shale outcrops.

G. Geological Resources

Extensive core drilling and mine mapping on Tracts C-a and C-b have revealed new information on the geology of oil shale which affects resource recovery, mining methods, and mining costs. First, there are significant variations in oil shale yield and pyrite abundance; these changes may be related to primary depositional patterns during Green River sedimentation. Variations in oil shale yield may require selective mining (or blending of ores) to achieve uniform feed grade to retorts. The variations in pyrite content change the concentration of sulfur in the waste gases from retorting and affect process costs. Second, rock structure exposed in outcrops of the Uinta or Green River Formation does not persist in the subsurface. Third, stratigraphically below the Mahogany Zone the structure of the north-dipping Green River Formation is complicated by northeast-trending folds with amplitudes up to 20 feet. These are compaction or slump folds. The rock strength in the folds, especially in the A and B Grooves, is very poor; additional rock bolts and concrete are needed in mine openings.

Data from core drilling as well as information on Green River stratigraphy, sedimentology, and oil shale resources are available at the OSO in Grand Junction.

H. Scenic and Cultural Values

No areas were disturbed on Tracts C-a or C-b that have not been evaluated for cultural resources. As required by the POSLP, lease, and DDP, studies on archaeological and cultural resources and scenic values have been made on the tracts and surrounding areas. During development to date, there have been no new discoveries of these resources. Although the headframes of the three shafts on Tract C-b are visible from Piceance Creek Road, visual resources have not been significantly affected by development to date.

I. Health and Safety

Extensive health and safety programs are conducted by lessees and their contractors. Programs include training of new personnel, on-the-job training, and refresher training. Certified instructors teach courses in mine rescue, mine emergency procedures, accident prevention, hazard awareness, use of mine safety equipment (i.e., self-rescue units, flame safety lamp, mine gas detection, oxygen analyzer, dust and noise control), first aid, and cardiopulmonary resuscitation.

Emergency medical service is provided 24 hours a day by emergency medical technicians (EMT's) who also participate in the ongoing training programs. Ambulances are always available on tract and a hospital helicopter is also available for extreme medical emergency.

Special attention has been given to methane in the mine workings. Special measurements are made during the mining cycle (i.e., during drilling and loading of explosives and both before and after blasting) and before electrical circuits are energized. Continuous methane measuring and recording systems have been placed at strategic locations in both mines. These systems activate audio and visual alarms when methane concentrations rise above a pre-set limit. When alarms sound, all personnel evacuate the area. The control, monitoring, and measurement of methane in the mines of C-a and C-b is a coordinated effort between the mine operators, federal and state safety regulators, and the OSO.

The incident rate for accidents on Tracts C-a and C-b is summarized in the table below. The incident rate for accidents on the federal tracts is significantly less than estimates of the oil shale industry average. The Health and Safety Analysis Center, U. S. Department of Labor, compared the incident rates for three types of mining operations. The incident rate for oil shale (13.87) is less than the incident rate for both underground coal (14.14) or metallic and nonmetallic underground mines (14.87).

Table 8

Tract	Manhours	Reportable Accidents	Lost Time Accidents	Incident Rate
C-a ¹	916,810	38	26	8.28
C-b ²	<u>783,871</u>	<u>20</u>	<u>15</u>	<u>5.10</u>
Totals	1,700,681	58	45	6.82

$$IR = \frac{\text{Incident Rate} = \frac{\text{Number of Reportable Accidents} \times 200,000}{\text{Hours of Employees' Exposure}}}$$

¹ C-a Company Report

² C-b 1980 Annual Report

A fatal accident occurred in 1980 in the Tract C-a Production Shaft at the Loading Pocket. Rock and water unexpectedly rushed through the chute gate and forced the operator through the guard gate into the shaft. Since the accident, the work station has been redesigned to avoid this problem.

Two studies are underway to determine the toxicity of oil shale and shale oil. One, conducted by the American Petroleum Institute (API), suggests that raw and processed shale are nontoxic and noncarcinogenic to rats or monkeys. Unrefined or raw shale oil is carcinogenic, but may be no more carcinogenic than average, conventional crude oil. Tests on refined and semirefined shale oils are currently underway. The second study, conducted by the U. S. Department of Energy, has been completed but the results have not been published.

J. Socioeconomics

Socioeconomic impact is recognized as a major consideration in the development of an oil shale industry. A typical 100,00 bpd plant will require a peak workforce of approximately 5,000 people. Associated direct and indirect population increases will be substantially greater than 5,000. Careful planning will be required to ensure the availability of adequate housing and municipal services and facilities. To assist in planning, the lessees have prepared socioeconomic assessments which accompany the submittal of the Detailed Development Plans. These reports may be referenced for more specific and complete information. The most recent report was submitted by White River Shale Corporation in late 1981 for the proposed development of Tracts U-a and U-b. C-b lessees have continued a community data monitoring program and provide this office with quarterly reports summarizing the results. In the past, the Colorado lessees have provided direct funding as well as community development experts to help offset the high costs of mitigating socioeconomic impact. As the projects continue to develop, it is expected that this type of assistance will continue. Tracts C-a and C-b continue to provide bus transportation and/or van pools for their employees from both Meeker and Rifle.

VI OSO SPECIAL PROJECTS

This section of the OSO Report describes research contracts funded or sponsored by OSO, papers by OSO staff published in professional journals, briefings prepared by OSO, and other activities related to oil shale development. It is included in this report to outline the directions in which oil shale development is proceeding, describe activities and contracts that will guide the POSLP in the near future, and summarize professional contributions of the OSO staff.

A. Contracts

The USGS/MMS has provided funds and technical management for a number of contract studies in support of the POSLP and oil shale in general as primarily benefits lease management. Listed below is a brief description of contract actions which have been fully or partially funded through this office during 1980-1981:

<u>Title</u>	<u>Amount</u>	<u>With</u>
Blair Mountain Visibility Station Establish a remote, automatic imaging and telephotometer station with three view paths over the Piceance oil shale basin and the Flat Tops Wilderness Area to complement data being gathered by the federal lessees from within the basin. Photographic data is received by the U.S. Forest Service and telephotometric data reads out to GOES satellite.	\$75,000	EPA Region VIII
Monument Peak Visibility Station Establish a remote, automatic telephotometric station with limited meteorologic data systems. The BLM ROWs have been obtained. A powerline has been run in to the site and the two telephotometer and related equipment procured, station will be constructed as soon as weather permits in 1982.	Included in above	EPA Region VIII
Evaluation of Montana Shales To drill two core holes on the Heath Formation shales of Montana to more fully evaluate earlier USGS findings of associated heavy metals. Drilling will commence in 1982 when weather permits.	\$220,000	Montana Bur of Mines
Evaluation of Uinta Basin For drilling of two 3,500' deep core holes near the depositional center of the Uinta Basin. The holes were completed in January 1982. Core analysis and report preparation by the USGS-GD is underway.	\$250,000	USGS-Geologic Divsn
Small Mammal & Avifauna Census Techniques To determine suitable techniques for censusing small mammal and avifauna populations in the oil shale basins (Tract C-a). Fall 1981 sampling for Phase I has been completed and a preliminary report prepared.	\$39,725	Batelle
Methane Source Modeling To develop a predictive model for methane occurrence in oil shale mine openings based on geotechnical data. U.S. Bureau of Mines preparing study proposal.	\$10,000	U.S. Bureau of Mines

Reprofile Hydro Model \$20,000 Potentially with WRD
To look at the feasibility of developing a long-term, predictive hydrologic model for the Piceance Basin considering different mining and reclamation techniques.

Palatability of Irrigated Rangeland \$ 5,000 Coop w/Nat'l Shrub Lab
To determine palatability and nutrient changes on big sage subject to stimulation by fertilization and irrigation (Tract C-b). Plants have been caged and productivity measurements taken. Utilization and chemical analysis to be completed in early 1982.

Sulfur Speciation in Oil Shale \$18,000 DOE
To monitor rate of production of sulfur species in RBOSC MIS test Retort #1 (Tract C-a) off-gas stream to determine amounts of sulfur species produced during the burn, rates of change, and characteristics toward end of burn. Data has been obtained and DOE is preparing preliminary report to be completed in early 1982.

B. Papers Published by the OSO Staff Include:

1. Sundquist, Eric J., and Miller, G. A., 1980, Oil shale and carbon dioxides: Science, v. 208.
2. Miller, G. A., 1981, Water availability and requirements for western oil shale development, in Environmental and Economic Considerations in Energy Utilization, Proceedings of the Seventh National Conference on Energy and the Environment: Ann Arbor Science.
3. _____, 1981, Synfuels/oil shale development and groundwater: Sixth Annual Water Workshop, Western State College, Gunnison, Colo.
4. Barker, Larry, 1982, A method of approximating energy and material balances from MIS retorting: submitted for review.

C. Formal Briefings and Presentations Made by the OSO Staff Include:

1. "Solid and hazardous waste management for federal oil shale tracts," given to the Colorado League of Women Voters.
2. "Oil shale development," given to the Colorado Division of Wildlife, Grand Junction Rotary Club, Western Colorado Museum Society, New Mexico Geological Society, staff of Senators Warner and Armstrong, touring college environmental and mineral management classes, and board members of the Synthetic Fuel Corporations.
3. "Researchable objectives for oil shale waste management," given to the Upper Colorado River Basin Aquatic Ecology Research Group.
4. "Federal Prototype Oil Shale Program: An environmental sampling approach," presented to Symposium on the Aquatic Resources Management of the Colorado River Ecosystem.

5. "Synfuels and oil shale development and ground water," presented at the 6th Annual Water Workshop, Western Colorado College.
6. "Case study II - Oil shale environmental monitoring program," for workshop on design and analysis of terrestrial environmental impacts, Louisiana State University.

D. Contributions Were Made to the Following Studies, Reports, and Research

1. USGS Piceance Basin ground water model;
2. Numerous R&D projects and reports sponsored by the National Academy of Science through the DOE Oil Shale Task Force;
3. Water-related effects of oil shale development support by the Water Resources Council;
4. Availability of water for oil shale and coal gasification prepared for the Water Resources Council;
5. Design for geochemical baseline studies in Colorado oil shale region prepared by DOE;
6. Composition of leachage from surface-retorted oil shale prepared by University of Colorado;
7. Impacts of in situ oil shale production prepared for DOE;
8. Overview of environmental problems of oil shale development on surface and ground water sponsored by EPA;
9. Geologic and economic evaluation of the White River Dam for the Utah Geologic and Mineral Survey;
10. Environmental effects of large-scale surface mining in the Piceance Basin for EPA;
11. Water assessment of the Rio Blanco Oil Shale Project for the USGS-WRD;
12. Oil shale risk assessment sponsored by DOE;
13. Environmental and health research plans for Retort "0", Tract C-a, for DOE;
14. Retort abandonment peer review for DOE;
15. Oil shale management research for DOE;
16. Deer movement telemetry study sponsored by Colorado Division of Wildlife and LAL;
17. Mitigation of wildlife losses from energy development sponsored by Colorado Division of Wildlife;

18. Bond procedures for federal oil shale tracts prepared by OSO staff;
 19. Geologists and mining engineers from the OSO completed a "Preliminary Mining Report for Land Exchange Application between the State of Utah and the United States of America in the NE portion of the Uinta Basin." Oil shale resources in place and resources recoverable from the Mahogany Zone were estimated for 5,804 acres of public lands selected for exchange and for 6,691 acres of Utah state lands offered in exchange.
- E. OSO Staff have also Participated or Contributed to the Following Conferences, Symposia, and Training:
1. "Soils and Rock Mechanics," at the University of Wisconsin;
 2. "Mine Shaft Design and Construction, University of Wisconsin;
 3. "Environmental Challenges of Oil Shale," the Oil Shale Task Force;
 4. "Air Quality Research Review," DOE, Gaithersburg, Maryland;
 5. "Colorado Clean Air Act Position," Denver;
 6. "Oil Shale Properties and Production," Colorado School of Mines;
 7. "Society of Range Managers Conference," Fort Collins, Colorado;
 8. "Review of Cultural Resources," Utah State Division of Oil, Gas, and Mining;
 9. "Reclamation/Revegetation Workshop," National Forest Service;
 10. "High Altitude Revegetation Symposium," State and Federal agencies;
 11. "Funding for Undergraduate Science Programs," National Science Foundation;
 12. "Regional Meteorological Modeling Needs," industry and government;
 13. "PSD Workshop," EPA;
 14. "Visibility Workshop," EPA;
 15. "Eastern Oil Shale Symposium," University of Kentucky;
 16. "Western Oil Shale Benefits, Risks, and Uncertainties," University of Colorado;
 17. "Hydrologic Aspects of Oil Shale," LBL; and

18. "The Oil Shale Symposium," Colorado School of Mines.
19. Several special meetings and advisory groups have been initiated by the OSO including Evaluation of Acid Rain and a field conference on Oil Shale Geology.

F. Public Information

Requests for environmental monitoring and development data, data analysis reports, and general oil shale information occur daily. Some requests are answered easily over the telephone, while others may require several hours of research and compilation of information. Requests for information are routinely received from members of Congress, private individuals, environmental groups, government agencies, private industry, university students and faculty, and research groups. To maximize the use of the vast amount of data generated by the POSLP, a special effort has been made to send relevant data reports to agencies who have concerns or expertise in areas critical to oil shale development. All monitoring and development data collected by the lessees are submitted to the MMS and in turn are provided to interested agencies and persons. File copies are maintained for public inspection at the OSO and selected summary reports are sent to region libraries.

APPENDIX A

CHRONOLOGY

The following chronology lists major administrative and development milestones of the Prototype Oil Shale Leasing Program to date.

6/29/71 Prototype Oil Shale Leasing Program (POSLP) was announced by the Secretary of the Interior.

- A preliminary environmental statement, program statement, and state reports on oil shale were released.
- Industry informational corehole drilling was authorized.

11/2/71 Department of the Interior requested oil shale lease tract nominations. Twenty tracts were nominated.

4/25/72 Six tracts were selected for leasing (two each in Colorado, Utah, and Wyoming).

8/29/73 Final environmental impact statement on the POSLP was submitted to CEQ, including:

- Regional impacts of a one million barrel-per-day industry.
- Anticipated impacts from development of the six selected lease tracts.
- Methods of shale oil production including conventional underground and open-pit mining with surface retorting, and in situ processing of oil shale.

January-June 1974 Prototype oil shale lease sale were held as follows:

<u>Lease</u>	<u>Sales Date</u>	<u>Effective Date</u>	<u>Original Lessees*</u>
C-a	1/8/74	3/1/74	Gulf, Standard (Indiana)
C-b	2/12/74	4/1/74	TOSCO, ARCO, Shell, Ashland
U-a	3/12/74	6/1/74	Phillips, Sun
U-b	4/9/74	6/1/74	White River Shale Project
W-a	5/14/74	**	--
W-b	6/11/74	**	--

* See Table 3 for listing of current lessees, bonus bid, and amount paid and offset to date.

**The Wyoming leases received no bids primarily because of the restricted resource base.

2/27/74 The Oil Shale Environmental Advisory Panel (OSEAP) was established by the Department of Interior and the first meeting was held on April 15, 1974. Purpose of the OSEAP is to:

- Provide for public participation and
- Advise Interior officials, particularly the Deputy Conservation Manager-Oil Shale and BLM District Managers, on the environmental aspects of the POSLP.

6/74 Oil Shale Office (OSO) was established within the Conservation Division, Central Region of the USGS to administer the POSLP.

5-8/74 Exploration and environmental baseline data plans were received from the lessees of the four prototype lease tracts.

- These plans were reviewed and approved with conditions by October 1974.
- Environmental baseline data collection commenced in the fall of 1974 and the required two years' worth of data were completed by the end of 1976.

12/23/75 TOSCO and ARCO withdrew as Tract C-b lessees stating that inflation, economics, and lack of government incentives made development of the lease unattractive. Shell and Ashland, the remaining lessees, continued work toward submittal of a Detailed Development Plan (DDP).

3-6/76 Lessees submitted lease-required DDPs as follows:

<u>Tract</u>	<u>Date</u>	<u>Development Method</u>
C-a	3/76	Open pit mining with indirect heated surface retorting
C-b	2/76	Underground mining with indirect heated surface retorting.
Ua/Ub	3/76	Underground mining with direct and indirect heated surface retorting.

- Over 200 copies of each DDP and related reports were distributed to OSEAP, interested agencies, individuals, and libraries.

3-7/76 Lessees applied for Suspension of Operations pursuant to Section 39 of the Mineral Leasing Act and the Oil Shale Lease.

- Tract C-b applied on March 4, 1976.
- Tract C-a applied on July 2, 1976.
- Lessees of Tracts U-a and U-b applied for a suspension on July 19, 1976. On September 27, 1976, the lessees withdrew their original suspension application and submitted a new application.

8-10/76 Suspensions of operations were granted for Tracts C-a and C-b in August 1976 and for Tracts U-a and U-b in October 1976 for the following reasons:

- All tracts: Data from the baseline air quality program showed that natural background amounts of non-methane hydrocarbons, ozone, and particulates on occasion exceeded National Ambient Air Quality Standards (NAAQS). EPA was consulted and worked on this issue during the suspension period.
- Tract C-b: On-tract geotechnical program revealed that rock strength was less than assumed from mines on the basin margins which would decrease resource recovery by room-and-pillar mining to an unacceptable degree.
- Tract C-a: Open pit development of this tract required the use of off-tract disposal sites. The Solicitor determined that the Department of Interior did not have authority to grant use of off-tract lands. Bills were introduced in Congress to authorize the use of off-tract lands.

11/2/76 Shell Oil Co. withdrew as a Tract C-b lessee. The remaining lessee, Ashland Oil, announced on November 4, 1976, a partnership with Occidental Oil Shale, Inc., for the purpose of using Oxy's modified in situ technology to develop Tract C-b.

12/21/76 Environmental Defense Fund, Colorado Open Space Council, Friends of the Earth, and Denver Audubon Society filed suit against the Department of the Interior questioning the basis on which suspension of operations was granted.

- This suit was dismissed based on the omission of indispensable parties and improper jurisdiction.

3/1/77 Tract C-b lessees submitted a modification to the DDP changing the direction of development from room-and-pillar mining with surface retorting to Oxy's modified in-situ (MIS).

5/18/77 Lessees of Tracts U-a and U-b filed suit against the Department of Interior seeking an injunction to indefinitely suspend lease due diligence requirements and bonus payments until conflicts with overlapping mining claims and state in-lieu land selection of the leased areas were resolved.

- A hearing on a preliminary injunction was held on June 3, 1977, and continued to June 8, 1977, when the injunction was granted.

5/25/77 Tract C-a lessees submitted a revision to their DDP changing the direction of development from open pit mining with surface retorting to MIS with surface retorting of development rock.

- 5/77 Tract C-a lessees submitted an application to extend suspension of operations beyond the September 1, 1977, expiration date, because the issue of NAAQS had not yet been resolved.
- 7/5/77 Regional Administrator for EPA Region VIII provided a technical support document as basis for an administrative opinion by EPA that presently measured air quality concentrations on the oil shale tracts do not preclude the development of the tract's resources. This resolved the NAAQS issue eliminating it as a valid issue for extending suspension of operations.
- 8/9/77 Interior Department Assistant Secretary for Energy and Minerals was provided technical review documents and a draft approval letter prepared by the DCM-OS for modification of the Tract C-b DDP and asked to concur in the Mining Supervisor's preliminary determination that the revised DDP be approved. Similar material was submitted for revision to the Tract C-a DDP.
- 8/30/77 Interior Assistant Secretary for Energy and Minerals concurred in approval of the modified DDP for Tract C-b and the approval letter was formally signed by the Mining Supervisor and the lessees. The letter contained 12 specific conditions regarding environmental protection, monitoring, water management, abandonment, and submission of engineering plans.
- 9/1/77 One year Suspensions of Operation for Tracts C-a and C-b were terminated and the request for an extension by the lessees of Tract C-a was denied.
- 9/22/77 Interior Assistant Secretary for Energy and Minerals concurred in the approval of the Revised DDP for Tract C-a and the approval letter was formally signed by the Mining Supervisor and the lessees. The letter contained 11 specific conditions regarding environmental monitoring, shale disposal, emission modeling for commercial phase, shale leachability, and submission of engineering plans.
- 12/6/77 Environmental Defense Fund, Colorado Open Space Council, and Friends of the Earth filed suit in United States District Court of Colorado seeking to enjoin development of Tracts C-a and C-b. Claimants felt that NEPA requirements had been violated and that approval of the DDP's and related rights-of-way should be overturned until a site-specific EIS was prepared.
- 1/78 American Mine Service Company, contractor for Rio Blanco Oil Shale Company (Tract C-a) began sinking the 15-foot diameter Service/Production Shaft. This shaft will be used primarily during the Modular Development Phase (initial test retorts). A Ventilation Shaft and a secondary Escape/Service Shaft will be upreamed after completion of the Service/Production Shaft.
- 2/78 A contract was let by the C-b Shale Oil Project (Tract C-b) to Gilbert Corporation to sink four shafts on Tract C-b (a 34-foot diameter Service Shaft, 29-foot diameter Production Shaft, 15-foot diameter Ventilation/Escape Shaft, and 10-foot diameter Temporary

Off-Gas Shaft. Shafts will be about 2,000 feet deep. Work began later that month on the Service and Production Shafts, and in May on the Ventilation/Escape Shaft. By December 1979 the shafts had been deepened to 744', 833' and 1,017' respectively. Use of formation grouting and full concrete lining has significantly limited ground water inflow to about 100 gpm in each shaft.

- 4/78 Approval subject to audit was given to bonus offsets for Tracts C-a and C-b totaling more than required fourth bonus payments.
- 5/78 American Mine Service, Inc., completed the openwork steel headframe on Tract C-a over the 15-foot diameter Service/Production Shaft. The headframe will be used for both shaft sinking, and mine and retort development.
- 8/8/78 U.S. Court of Appeals ruled in favor of the State of Utah's claim to over 157,000 acres of in-lieu land selections encompassing Tracts U-a and U-b. On September 22, 1978, the Department of Interior filed a motion for rehearing before the Tenth Circuit Court which upheld the lower court ruling. This enjoined the Federal Government from enforcing lease terms on the Utah tracts and placed them under indefinite suspension of operations. Limited environmental monitoring was continued. The Department of Interior has appealed the case to the U.S. Supreme Court.
- 8/78 Weyre Construction Corp. completed the 178-foot high concrete slipformed Service Shaft hoist tower at the Mine Support Area on Tract C-b. The tower was completed in 10 days of continuous pouring and will house hoisting equipment for lowering workers and equipment into the commercial mine beneath Tract C-b.
- 8/25/78 Judge Finesilver of the U. S. District Court issued a summary judgment dismissing the December 6, 1977, suit filed by the Environmental Defense Fund, Colorado Open Space Council, and Friends of the Earth. The court held that the 1973 EIS for the POSLP was sufficient for DDP and rights-of-way approval, and that procedures of the DCM-OS were more than adequate to fulfill the requirements of NEPA. This summary judgment was appealed by the Plaintiffs.
- 9/78 Ruscon, Becon, and Associates, and The Industrial Company began work on the Tract C-b MDP retort production treatment plant.
- 10/78 Weyre Construction Corp. completed the 313-foot high concrete slipformed Production Shaft hoist tower at the Mine Support Area on Tract C-b. The tower, with walls no less than two feet thick, was raised in 26 days of continuous pouring and will house hoisting equipment for commercial mine and retort development.
- 12/15/78 Ashland Colorado, Inc., announced withdrawal from Tract C-b effective February 14, 1979. This left Occidental Oil Shale, Inc., as the sole lessee. Ashland indicated that withdrawal from the C-b Project was prompted by economic studies that suggest increased capital and operating costs may reduce profitability in the face of technical, political, and regulatory uncertainties.

- 12/78 Western Slope Gas Company completed installation of a 4-1/2 inch natural gas service pipeline to Tract C-b. Natural gas will be used for on-tract electrical power generation for shaft sinking and related facilities. A majority of this power load will be switched to a 138 KVA powerline to be built from Meeker, Colorado, to Tract C-b. A similar pipeline was completed into Tract C-a in August 1979.
- 4/1/79 Tenneco Oil Company acquired half interest in Tract C-b with Occidental Oil Shale, Inc. Tenneco paid \$110 million for half interest in the project and will share costs 50-50 after April 1.
- 3-5/79 Lessees submitted their first detailed Annual Reports (for 1978 operating year) summarizing initial development and monitoring including analyses of environmental data through the baseline period.
- 4/79 Approval subject to audit was given to bonus offsets for Tracts C-a and C-b totaling more than required fifth bonus payments.
- 6/79 American Mine Services, Inc., completed the 10-foot diameter, 830-foot deep raise-bored Ventilation/Escape Shaft on Tract C-a. Drilling began for placement of rubblizing charges to create the first MDP MIS retort chamber (Retort 0) on Tract C-a. The 30' x 30' x 170' high retort will be ready for ignition by late 1980.
- 10/79 American Mine Service, Inc., completed the 15-foot diameter concrete lined Service/Production Shaft on Tract C-a to a depth of 979 feet. The shaft will be used to develop initial in-situ retorts, hoist mined rock, and move men and equipment.
- 11/29/79 Environmental Defense Fund filed an appeal to the U.S. District Court ruling which was contrary to their motion to have approval of DDP's for the two Colorado tracts overturned until a site-specific EIS was prepared.
- 11/30/79 Mine Health and Safety Administration declared the mine on Tract C-a to be "gassy" due to two minor methane ignitions in areas where cutting torches were in use.
- 12/5/79 U.S. Supreme Court heard the Federal Government's appeal to the August 8, 1978, Tenth District Court of Appeals ruling on Utah's in-lieu land case. No final ruling has yet been handed down.
- 12/79 The Modular Development Phase program for Tract C-a was changed to include three modified in situ (MIS) test retorts of increasing size ("0" = 30' x 30' x 167' high; "1" = 60' x 60' x 400' high; and "2" = 60' x 150' x 400' high) to be constructed and operated at the on-tract mine development area beginning in early 1980 through 1984 prior to decision on commercialization design. Each of these retorts would be developed by a system of blastholes drilled from the surface through 400' to 700' of overburden. Approximately 40

percent of the rubblized shale would be withdrawn through the mine production level to create adequate rubble void space to facilitate a "fast" in situ burn.

1/2/80 On January 2, 1980, the C-b shafts and limited mine workings were also declared gassy due to methane measurements in mine ventilation air.

1/80 The 15' diameter, 979' deep Service and Production Shaft on Tract C-a was fully equipped with shaft guides, man trip, underslug ore skip, and headframe mounted 50-ton ore bin. Eastward drifting began in earnest on the "Sub-E" dewatering level and "G" production level for development of the three MIS test retorts.

A 1771' deep test reinjection well was drilled adjacent to a 5 acre/foot surge pond excavated near the south boundary of Tract C-b. A three-phase test was conducted here to determine feasibility of reinjection on tract as a means of mine water disposal under varying pumping rates.

2/80 Drilling of the blastholes for rubblization of Retort "0" was completed on Tract C-a through approximately 700' of overburden. Staged blasting and mucking out of approximately 40 percent of the rubbed oil shale through the production level will be used to create a 30' x 30' x 167' high retort chamber. Ignition to be achieved by lowering burners down selected blastholes and forcing air and steam down others. Product oil and gas will be withdrawn through sealed portions of the production level to surface storage and off-gas scrubbing facilities.

With installation of the 25-ton bridge crane, the permanent hoist building at the 15' diameter Ventilation/Escape Shaft near the north Tract C-b boundary was fully operational. The hoist will be used in shaft sinking and afterwards permanently equipped for initial MIS retort development while production drifting is started from the larger Service and Production Shafts to the south.

3/3/80 The Tenth Circuit U.S. Court of Appeals issued a ruling upholding a lower court's decision that the 1973 EIS for the FPOSLP is adequate. This case is Environmental Defense Fund, et al. vs. Andrus, et al. EDF filed a petition for a rehearing on March 17 and the Appeals Court denied the petition on May 6.

3/6/80 A muck flow in the Service/Production Shaft loading pocket on Tract C-a swept the chute operator over the safety railing to his death. The loading pocket was subsequently redesigned to prevent reoccurrence of such an accident.

3/80 Upreaming was commenced on the 10' diameter, 840' deep Service/Escape Shaft on Tract C-a. Headframe and shaft equipping was completed by April.

4/80 Baffles were installed in the mine water treatment ponds on Tract C-b to improve settling of fines in mine water. Automatic acid and flocculent metering systems were added.

- 4/30/80 Sohio, Phillips and Sunoco filed a compliant in the U. S. District Court in Salt Lake City, Utah, seeking to ensure that lease monies paid for Tracts U-a and U-b will revert to the lessees if state and federal agencies fail to clear the title to the leased lands in a timely manner.
- 5/8/80 The first rubblization blast round for Retort "0" on Tract C-a was touched off. Rubble withdrawn through the production level was placed over a system of raw shale lysimeters in the mined material storage area to determine composition of leachate waters formed by natural weathering conditions.
- 5/19/80 U.S. Supreme Court issued a 5-4 opinion upholding the Department of the Interior's position in the Utah "in-lieu" land case and reversing previous lower court decisions.
- 6/26/80 Rubblization of Retort "0" on Tract C-a was completed forming a retort chamber approximately 30' x 30' x 170' high. Downhole piping for retort ignition and operation was completed in July, followed by bulkheading and leak pressure testing in September.
- 6-7/80 Completed upreaming and support of 840' deep by 8' diameter instrument shaft, 5' diameter retort off-gas shaft, 2' diameter water transfer raise, and 12 assundry utility boreholes on Tract C-a for operation and monitoring of MIS test Retorts "0" and "1".
- 6/80 Began construction of switchyard and substation facilities on Tract C-b for the 138 KV Meeker-to-tract powerline to be constructed in the spring of 1981. This system will supply power needed for initial commercial mining and MIS retort operation until sufficient surplus retort off-gas is available to generate all on-tract power needs. The existing 9-unit diesel-generator plant used for shaft sinking will provide standby power.
- 7/80 Began piping up test reinjection well on Tract C-b and installation of filter plant to polish and de-oxygenate water prior to injection to prevent early plugging of the receiving zones.
- 7/3/80 Approval was granted to Tract C-b for operation and monitoring of a large area sprinkler system for disposal of 400 gpm of treated mine water on undisturbed upland sage and pinion juniper.
- 8/80 Driving on the "G" production level, Tract C-a, for MIS test retort development was completed. The "Sub-E" dewatering level was fully drifted in early September.
- 8/15/80 The USGS-Oil Shale Office (OSO) approved use of the newly-formed Colorado Joint Review Process for evaluation of the modification to the Detailed Development Plan (DDP) for Tract C-a to include operation of a 4,400 TPD above ground Lurgi test retort and associated 36-acre open pit mine in the northwest corner of the tract.

- 9/80 The 5,000' long dirt airstrip near Tract C-a at 84 Mesa was lengthened and paved allowing direct service to the Piceance Basin by general class twin-engine aircraft. The OSO maintains a vehicle at the strip for commuting directly to the lease tracts.
- The bulkhead construction for Retort "0" was completed and the retort system pressure tested for leaks. The downhole burner was installed. Outfitting of the Service/Escape Shaft and Instrument Shaft was completed.
- Three raw shale lysimeters were constructed at the run-of-mine disposal area on Tract C-b to evaluate leachate composition generated under prevailing precipitation and weathering conditions. By November, the lysimeters were filled with 4,000 tons of shale. Samples through mid-1981 show high levels of dissolved solids.
- 10/6/80 The OSO approved the process stream and emission monitoring program for Retort "0" on Tract C-a.
- 10/13/80 Retort "0" on Tract C-a was ignited with a sustained burn achieved on the 14th.
- 10/20/80 BLM granted right-of-way to Tract C-b for construction of 138 KV Meeker-to-tract powerline. Construction will begin in the summer of 1981.
- 10/31/80 OSO approved construction of an access road to the area north of Tract C-a where the Lurgi 4,400 TPD surface test retort and processed shale disposal areas would be built on land to which the lessees had purchased surface use rights from the Colorado Division of Wildlife. Construction was completed in December.
- 11/80 Rubblization began on MIS test Retort "1" on Tract C-a, using the same surface borehole blasting technique developed for Retort "0". By year end rubblization of Retort "1" was 75 percent complete and would ultimately produce a chamber 60' x 60' x 400' high with a burn life of nearly four months.
- Occidental Oil Shale, Inc., operator of Tract C-b, applied for \$4.3 billion in loan guarantees under the Defense Production and Non-Nuclear Acts (an amount equal to an estimated 75 percent of tract development costs).
- 11/3/80 Lessees of Tracts U-a and U-b submitted their final draft DDP to the OSO and the Oil Shale Environmental Advisory Panel for comment. The development scheme calls for an ultimate 106,300 bbls/day shale oil production using joint mining and retorting of shale from the two tracts using conventional large area room-and-pillar mining methods and surface retorting with Paraho and Union type retorts. Paraho retorts were later replaced during initial development by Superior units.

- 12/20/80 Retort "0" burn on Tract C-a was officially terminated. Oil accumulated over the three month burn equalled approximately 1040 barrels with an additional potentially recoverable 710 barrels incinerated in the off-gas scrubber system.
- 12/31/80 Tract C-a had completed 3-1/2 years of their 4-year commercial feasibility program, excavated 9,220' of mine workings, reamed 2,520' of mine shafts, mined 121,110 tons of rock and oil shale, disturbed 35 acres (222.8 acres to date), reclaimed 22 acres (112.8 acres to date), expended \$48,280,000 for tract development in 1980, and employed up to 455 workers per month.
- Tract C-b had added 36,250 square feet of office, shop, laboratory, and warehouse space; 597 million gallons of ground water were pumped, 296 million gallons treated and released, with remainder used or disposed of on-tract; 309,289 gallons of fuel and 618,659 mm Btu of natural gas consumed; 86,000 cubic yards of rock mined; 15.8 acres disturbed (172 to date); 33 revegetated (24 to date); a peak of 481 employed; and \$50,512,500 expended for tract development in 1980.
- 1/81 Rubblization of Retort "1" on Tract C-a was completed creating a rubble chamber approximately 60' x 60' x 400' high. Drilling of longholes from the adjacent upreamed shaft for installation of monitoring equipment began.
- 1/81 The run-of-mine material pile at the east end of the mine development area on Tract C-a was observed to be spontaneously heating. The lessee partly excavated the heating area and by February had installed a series of thermocouple strings to monitor heat buildup and spread throughout the pile. Subsurface samples were taken for laboratory analysis. Heating continued to approximately 150° F and then began to drop back to ambient ground temperature. Cause of heating is still being investigated.
- 1/15/81 OSO completed review of the Draft DDP Modification for Tract C-a that proposed inclusion of a 440 TPD Lurgi retort test module north of the tract with test shale to be largely derived from a 36-acre open pit to be excavated in the northwest corner of the tract.
- 2/2/81 Based on OSO and other comments, the C-a lessees submitted the final version of their DDP Modification for formal review by the OSO. Public hearings were held on March 26th in Meeker and on April 3rd in Denver.
- 2/18/81 OSO approved the monitoring program for the reinjection test to be carried out on Tract C-b.
- 2/27/81 OSO approved revision #6 to the Tract C-a Monitoring Program Scope of Work.

- 3/81 Comprehensive flow, leak, and tracer tests were run on Retort "1" on Tract C-a.
- Phase I reinjection test began on Tract C-b and achieved a sustained 30-day, 153 gpm flow rate. On March 31, 1981, the flow rate was increased to 300 gpm. The pre-injection filter plant achieved round-the-clock operation delivering water to the wellhead with less than 1 ppm suspended solids.
- Harrison Inc. began mobilizing equipment to Tract C-b to install permanent hoist equipment in the Service and Production Shaft headframes.
- 4/81 Brown and Root, Inc., began backfilling the west side of the Tract C-b mine support area for foundation areas for the permanent warehouse and change house.
- 4/13/81 Lessees of Tract C-b submitted a revised PSD permit application to EPA to cover increased production of 117,000 barrels per day and above ground retorting of oil shale directly mined for MIS retort preparation.
- 4/21/81 Concurrence was received from the U.S. Fish & Wildlife Service in the Biological Assessment for threatened and endangered species in the Tract C-a vicinity clearing the way for further development.
- 4/28/81 Tract C-a announced a delay in starting construction of the Lurgi surface demonstration project. Retort "1" ignition would also be delayed while formation fractures adjacent to the retort were sealed.
- 4/30/81 Gilbert, Inc., bottomed the 34' diameter Service Shaft on Tract C-b at design depth of 1757' below collar (upper R-5 Zone). Temporary shaft utilities were removed and the sinking galloway was modified to install permanent utilities, hoist guide, and wiring.
- 5/1/81 The C-a DDP Modification for the Lurgi open pit test was approved by the OSO.
- 5/20/81 Phase III, 450 gpm reinjection test was started on Tract C-b. Subsequent pump and wellhead failures forced repeated test stoppage.
- 5/27/81 EPA issued Tract C-b a Notice of Violation (NOV) under the NPDES permit for discharge of treated mine water that still contained above permit levels of fluoride based on the lessee's self-report data. Subsequent downstream tests revealed that the fluoride level was rapidly reduced to acceptable levels by dilution. In August, the Colorado State Attorney's Office requested EPA to rescind the NOV as the lessee had made request for criteria change as there is no legal basis for the F level in the present permit.

- 7/81 Tract C-a - Initial construction of Stage III sour water ponds began. Lining of Stage III sour water ponds began. Excavation began on the slurry trench test to test slurry grouting of a retort. The smoke stack developed a leak.
- 6/21/81 Retort "1" on Tract C-a was ignited and achieved sustained burn. As of July, 5,000 bbls of oil had been recovered and burn rate was advancing as predicted.
- 6/23/81 OSO approved drilling of additional injection wells on Tract C-b.
- 6/25/81 The Phase II reinjection program on Tract C-b was completed at an average of 445 gpm. Permanent pumping equipment was installed and reinjected 450-500 gpm excess mine water. No water was discharged to natural drainages.
- 8/81 Tract C-a - Repairs to stack corrosion were made. Retort "1" burn continued. Leak testing of sour water ponds began.
- 8/26/81 The Ventilation/Escape Shaft was bottomed on Tract C-b at the design depth of 1617' below collar. The lessee temporarily flooded the shaft to reduce pumping and water handling costs until drifting from the Service Shaft reaches the V/E shaft area in late 1982. By December 1981, water had risen to 124' of the shaft collar.
- 9/1/81 WRSP submitted the final DDP for an ultimate 106,300 bbls/day shale oil production using room-and-pillar mining and above ground retorting.
- 9/81 Tract C-a - Leaks were again discovered in the stack which necessitated flaring of off-gas and shutdown of air to the retort.
- The 138-KV powerline from Meeker to Tract C-b was strung. It was tested in January 1982.
- 9/29/81 The 29' diameter Production Shaft on Tract C-b was completed to design depth of 1,867'. Methane levels were nil throughout sinking. Loading pockets and clean out drift were completed. Work is underway on the last of the shaft steel sets and installation of the hoist works for four 52.5 ton ore skips.
- 10/21/81 Tract C-a - The steel stack was repaired and relined and air returned to Retort "1".
- Public hearings were held in Vernal, Utah, on the WRSP DDP.
- 10/28/81 Public hearings were held in Salt Lake City, Utah, on the WRSP DDP.
- 12/17/81 Occidental Petroleum and Tenneco announced a delay in Tract C-b development. Engineering studies suggested that in situ and surface retorting are not feasible at the scale planned, or at current construction costs, interest rates, and oil prices. On February 1, 1982, 85 people will be laid off. Outfitting of the shafts and headframe will continue while engineering alternatives are examined.

12/22/81 RBOSC announced over 24,000 barrels of oil were produced from Retort "1". When data from Retorts "0" and "1" are analyzed, the MIS demonstration program on C-a will be complete. \$140 million has been expended to demonstrate the two retorts.

APPENDIX B
LOCATION AND DESCRIPTION OF PROTOTYPE TRACTS

Federal Oil Shale Tract C-a (Lease No. C-20046) is located in the Piceance Creek Basin, Rio Blanco County, Colorado, 58 miles (43 km) northwest of Rifle and 51 miles (82 km) southwest of Meeker, Colorado. Tract C-b (Lease No. C-20341) is also located in the Piceance Creek Basin, Rio Blanco County, Colorado, 40 miles (61 km) northwest of Rifle and 40 miles (61 km) southwest of Meeker. The two Utah tracts, U-a and U-b (Lease No.'s U-25918 and U-26194) are located in the Uinta Basin, Uintah County of northeastern Utah, 42 miles (68 km) southeast of Vernal, Utah, and 30 miles (48 km) southwest of Rangely, Colorado.

Tract locations are depicted in Figures 1 and 3 and are more particularly described as follows:

Colorado

Tract C-a

T1S, R99W, 6th P.M.
Sec. 32, E1/2, E1/2W1/2;
Sec. 33, all;
Sec. 34, W1/2, SE1/4, W1/2NE1/4, SE1/4NE1/4

T2S, R99W, 6th P.M.
Sec. 3, all;
Sec. 4, all;
Sec. 5, E1/2, E1/2W1/2 (incl. Lots 1, 2, and 3);
Sec. 8, E1/2;
Sec. 9, all;
Sec. 10, all.

The area described aggregates 5,089.7 acres (2,061.3 ha).

Tract C-b

T3S, R96W, 6th P.M.
Sec. 5, W1/2SE1/4, SW1/4;
Sec. 6, Lots 6 and 7, E1/2SW1/4, SE1/4;
Sec. 7, Lots 1, 2, 3, & 4, E1/2W1/2, E1/2;
Sec. 8, W1/2NE1/4, NW1/4, S1/2;
Sec. 9, SW1/4;
Sec. 16, NW1/4, W1/2SW1/4;
Sec. 17, all;
Sec. 18, Lots 1, 2, 3, & 4, E1/2W1/2, E1/2.

T3S, R97W, 6th P.M.
Sec. 1, S1/2;
Sec. 2, SE1/4;
Sec. 11, E1/2;

Sec. 12, all;
Sec. 13, N1/2;
Sec. 14, N1/2NE1/4.

The area described aggregates 5,093.9 acres (2,063.0 ha).

Utah

Tract U-a

T10S, R24E, S.L.M.
Sec. 19, E1/2;
Sec. 20, all;
Sec. 21, all;
Sec. 22, all;
Sec. 27, all;
Sec. 28, all;
Sec. 29, all;
Sec. 30, E1/2;
Sec. 33, N1/2;
Sec. 34, N1/2.

The area described aggregates 5,120.0 acres (2,073.6 ha).

Tract U-b

T10S, R24E, S.L.M.
Sec. 12, S1/2, S1/2N1/2;
Sec. 13, all;
Sec. 14, all;
Sec. 23, all;
Sec. 24, all;
Sec. 25, W1/2W1/2;
Sec. 26, all.

T10S, R25E, S.L.M.
Sec. 18, all;
Sec. 19, all.

The area described aggregates 5,120.0 acres (2,073.6 ha).







